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<b>(21) International Application Number:</b> PCT/US93/10168 <b>(22) International Filing Date:</b> 22 October 1993 (22.10.93)  <b>(30) Priority data:</b> 07/965,662 23 October 1992 (23.10.92) US 08/112,608 26 August 1993 (26.08.93) US  <b>(71) Applicant:</b> GENETICS INSTITUTE, INC. [US/US]; 87 Cambridge Park Drive, Cambridge, MA 02140 (US).  <b>(72) Inventors:</b> LARSEN, Glenn, R. ; 112 Maynard Farm Road, Sudbury, MA 01776 (US). SAKO, Dianne, S. ; 50 Jamaica Way # 6, Boston, MA 02130 (US). CHANG, Xiao-Jia ; 59 Commonwealth Park West, Newton Centre, MA 02159 (US). VELDMAN, Geertruida, M. ; 60 Woodmere Drive, Sudbury, MA 01776 (US).		<b>(74) Agent:</b> MCDANIELS, Patricia, A.; Genetics Institute, Inc., 87 CambridgePark Drive, Cambridge, MA 02140 (US).  <b>(81) Designated States:</b> AU, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> NOVEL P-SELECTIN LIGAND PROTEIN  <b>(57) Abstract</b>  A novel P-selectin ligand glycoprotein is disclosed, characterized by the amino acid sequence set forth in SEQ ID NO:1 or by the amino acid sequence set forth in SEQ ID NO:3. DNA sequences encoding the P-selectin ligand protein are also disclosed, along with vectors, host cells, and methods of making the P-selectin ligand protein. Pharmaceutical compositions containing the P-selectin ligand protein and methods of treating inflammatory disease states characterized by P-selectin-mediated intercellular adhesion are also disclosed.		

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/10168

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>					
IPC 5	C12N15/12 C12N9/64	C12N15/62 C07K13/00	C12N15/54 C07K15/28	C12N15/57 A61K37/02	C12N9/10
According to International Patent Classification (IPC) or to both national classification and IPC					
<b>B. FIELDS SEARCHED</b>					
Minimum documentation searched (classification system followed by classification symbols)					
IPC 5 C12N C07K A61K					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched					
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)					
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>					
Category *	Citation of document, with indication, where appropriate, of the relevant passages				Relevant to claim No.
X	J. CELL BIOLOGY vol. 118, no. 2, July 1992, ROCKEFELLER UNIV. PRESS, N.Y., US; pages 445 - 456 K.L. MOORE ET AL. 'Identification of a specific glycoprotein ligand for P-selectin (CD62) on myeloid cells' cited in the application				12, 13
Y	see page 452, right column, paragraph 2 - page 455, left column, paragraph 1 ---				1-11, 14-20
X	WO, A, 92 01718 (REGENT OF THE BOARD OF THE UNIVERSITY OF OKLAHOMA) 6 February 1992 see claim 39 ---				12, 13
X	WO, A, 91 06632 (NEW ENGLAND MEDICAL CENTER HOSPITALS, INC.) 16 May 1991 see page 17, line 33 - page 18, line 6 ---				19
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.					
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## INTERNATIONAL SEARCH REPORT

national Application No  
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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,92 16612 (NEW ENGLAND MEDICAL CENTER HOSPITALS, INC.) 1 October 1992 see page 32, line 17 - page 37, line 9; claims 1-21 see page 37, line 13 - page 38, line 21 ---	19
A	J. BIOL. CHEM. vol. 267, no. 16 , 5 June 1992 , AM. SOC. MOL. BIOL., INC., BALTIMORE, US; pages 11104 - 11110 G.R. LARSON ET AL. 'P-selectin and E-selectin' cited in the application see page 11104, left column, line 1 - line 41 ---	1-20
P,Y	WO,A,92 19735 (GENENTECH, INC.) 12 November 1992 see page 17, line 10 - line 37; claims 1-38 ---	1-11, 14-20
P,X	BIOCHEM. BIOPHYS. RES. COMMUN. vol. 188, no. 2 , 30 October 1992 , ACADEMIC PRESS, N.Y., US; pages 760 - 766 C.N. STEININGER ET AL. 'The glycoprotease of Pasteurella haemolytica A1 eliminates binding of myeloid cells to P-selectin but not to E-selectin' see page 765, line 1 - page 766, line 10 -----	19

# INTERNATIONAL SEARCH REPORT

Information on patent family members

national Application No

PCT/US 93/10168

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9201718	06-02-92	AU-A- 8620791	18-02-92
		CA-A- 2086323	18-01-92
		EP-A- 0544815	09-06-93
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		EP-A- 0584194	02-03-94
		EP-A- 0584229	02-03-94
		WO-A- 9219761	12-11-92

TITLE OF THE INVENTION

## NOVEL P-SELECTIN LIGAND PROTEIN

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BACKGROUND OF THE INVENTION

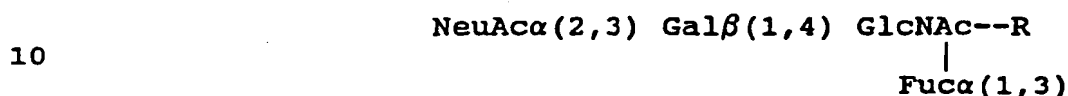
15 The present invention relates to the field of anti-inflammatory substances which act by inhibiting leukocyte adhesion to endothelial cells. More particularly, the present invention is directed to a novel ligand for the mammalian adhesion protein known as "P-selectin."

20 During inflammation leukocytes adhere to the vascular endothelium and enter subendothelial tissue, an interaction which is mediated by specific binding of the selectin or LEC-CAM class of proteins to ligands on target cells. Such selectin-mediated cellular adhesion also occurs in thrombotic disorders and parasitic diseases and may be implicated in metastatic spread of  
25 tumor cells.

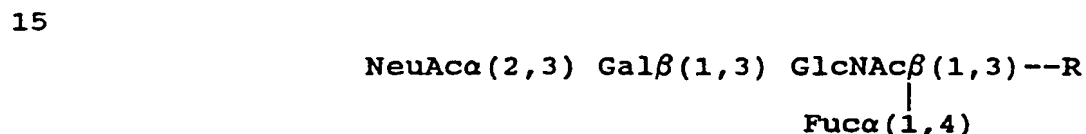
The selectin proteins are characterized by a N-terminal lectin-like domain, an epidermal growth factor-like domain, and regions of homology to complement binding proteins. Thus far three human selectin proteins have been identified, E-selectin  
30 (formerly ELAM-1), L-selectin (formerly LAM-1) and P-selectin (formerly PADGEM or GMP-140). E-selectin is induced on endothelial cells several hours after activation by cytokines, mediating the calcium-dependent interaction between neutrophils and the endothelium. L-selectin is the lymphocyte homing  
35 receptor, and P-selectin rapidly appears on the cell surface of platelets when they are activated, mediating calcium-dependent adhesion of neutrophils or monocytes to platelets. P-selectin is also found in the Weibel-Palade bodies of endothelial cells; upon its release from these vesicles P-selectin mediates early

binding of neutrophils to histamine-or thrombin-stimulated endothelium.

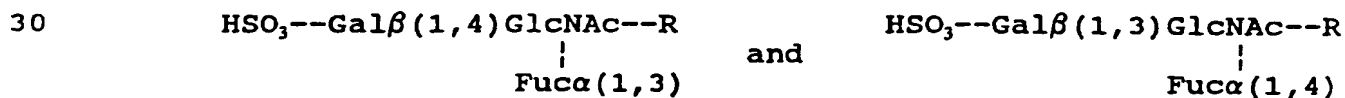
Selectins are believed to mediate adhesion through specific interactions with ligands present on the surface of target cells. Generally the ligands of selectins are comprised at least in part of a carbohydrate moiety. For example, E-selectin binds to carbohydrates having the terminal structure



and also to carbohydrates having the terminal structure



where R =the remainder of the carbohydrate chain. These carbohydrates are known blood group antigens and are commonly referred to as sialylated Lewis<sup>x</sup> and sialylated Lewis<sup>a</sup>, respectively. The presence of the sialylated Lewis<sup>x</sup> antigen alone on the surface of an endothelial cell may be sufficient to promote binding to an E-selectin expressing cell. E-selectin also binds to carbohydrates having the terminal structures



As with E-selectin, each selectin appears to bind to a range of carbohydrates with varying affinities. The strength of the selectin mediated adhesive event (binding affinity) may also depend on the density of the carbohydrate and on the density of the selectin on the cell surface.



P-selectin binds to carbohydrates containing the non-sialylated form of the Lewis<sup>x</sup> blood group antigen and with higher affinity to sialylated Lewis<sup>x</sup>. P-selectin may also recognize sulfatides, which are heterogeneous 3-sulfated galactosyl ceramides, isolated from myeloid and tumor cells by lipid extraction. However, the binding of cells bearing P-selectin to cells bearing P-selectin ligands is abolished when the ligand-bearing cells are treated with proteases, indicating that the P-selectin ligand may be a glycoprotein.

Two putative glycoprotein ligands for P-selectin have recently been identified, one of which has been partially purified, (Moore et al., J. Cell Biol. 118, 445-456 (1992)). However, neither amino acid composition nor the amino acid sequence of these glycoproteins are disclosed.

#### SUMMARY OF THE INVENTION

In one embodiment, the present invention provides a composition comprising an isolated DNA sequence encoding a P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402. Also provided is a composition comprising an isolated DNA sequence encoding a soluble P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 310. The invention further provides a composition comprising an isolated DNA sequence encoding a mature P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402. In another embodiment, the invention provides a composition comprising an isolated DNA sequence encoding a soluble mature P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310. In another embodiment, the invention provides a composition comprising an isolated DNA sequence encoding a P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:3. The invention further provides a composition comprising

an expression vector comprising any one of the isolated DNA sequences of the invention, said DNA sequence being operably linked to an expression control sequence; a host cell transformed with the expression vector containing any one of the DNA sequences described above; and a process for producing the P-selectin ligand protein, which comprises:

- (a) culturing a host cell transformed with an expression vector containing any one of the DNA sequences of the invention in a suitable culture medium; and
- (b) purifying the P-selectin ligand protein from the culture medium.

In another embodiment, the invention provides a composition comprising a protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 21 to amino acid 402, said protein being substantially free from other mammalian proteins. The invention further comprises a soluble P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 21 to amino acid 310, said protein being substantially free from other mammalian proteins, and in another embodiment, the invention comprises a P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402, said protein being substantially free from other mammalian proteins. The invention also provides a composition comprising a mature P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402, said protein being substantially free from other mammalian proteins. Further provided is a composition comprising a soluble mature P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310, said protein being substantially free from other mammalian proteins. In another embodiment the invention provides a composition comprising a protein characterized by the amino acid sequence set forth in SEQ ID NO:3.

In yet another embodiment, the invention provides a composition comprising an antibody specific for the P-selectin ligand protein.

In another embodiment, the invention provides a method of identifying an inhibitor of P-selectin-mediated intercellular adhesion which comprises

5 (a) combining a P-selectin protein with a P-selectin ligand protein characterized by an amino acid sequence selected from the group consisting of the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402, the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402, the amino acid sequence set forth in SEQ ID NO:1 from amino acid 10 42 to amino acid 310, and the amino acid sequence set forth in SEQ ID NO:3, said combination forming a first binding mixture;

(b) measuring the amount of binding between the P-selectin protein and the P-selectin ligand protein in the first binding mixture;

15 (c) combining a compound with the P-selectin protein and the P-selectin ligand protein to form a second binding mixture;

(d) measuring the amount of binding in the second binding mixture; and

20 (e) comparing the amount of binding in the first binding mixture with the amount of binding in the second binding mixture; wherein the compound is capable of inhibiting P-selectin-mediated intercellular adhesion when a decrease in the amount of binding of the second binding mixture occurs.

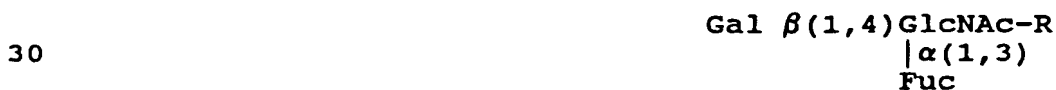
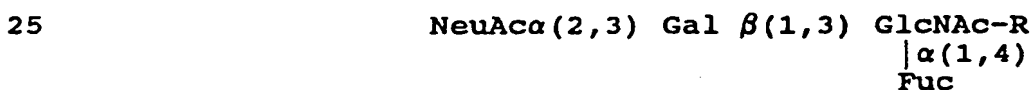
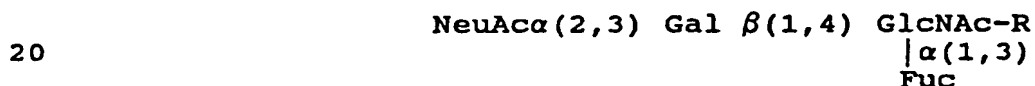
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#### DETAILED DESCRIPTION OF THE INVENTION

The present inventors have for the first time identified and isolated a novel DNA which encodes a protein which acts as a  
30 ligand for P-selectin on human endothelial cells and platelets. The complete amino acid sequence of the P-selectin ligand protein (i.e., the mature peptide plus the leader sequence) is characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402. Hydrophobicity analysis and  
35 comparison with known cleavage patterns predict a signal sequence of 20 to 22 amino acids, i.e., amino acids 1 to 20 or amino acids 1 to 22 of SEQ ID NO:1. The P-selectin ligand protein contains

a PACE (paired basic amino acid converting enzyme) cleavage site (-Arg-Asp-Arg-Arg-) at amino acids 38-41 of SEQ ID NO:1. The mature P-selectin ligand protein of the present invention is characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402. A soluble form of the P-selectin ligand protein is characterized by containing amino acids 21 to 310 of SEQ ID NO:1. Another soluble form of the mature P-selectin ligand protein is characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310. The soluble form of the P-selectin ligand protein is further characterized by being soluble in aqueous solution at room temperature. Of course, the corresponding DNA sequences as set forth in SEQ ID NO:1 encoding these proteins are also included in the subject invention.

15           The P-selectin ligand of the invention is a glycoprotein  
which may contain one or more of the following terminal  
carbohydrates:



40     where R= the remainder of the carbohydrate chain, which is covalently attached either directly to the P-selectin ligand protein or to a lipid moiety which is covalently attached to the P-selectin ligand protein. The P-selectin ligand glycoprotein of the invention may additionally be sulfated or otherwise post-

translationally modified. As expressed in COS and CHO cells, full length P-selectin ligand protein (amino acids 1 to 402 of SEQ ID NO:1 or amino acids 42 to 402 of SEQ ID NO:1) is a homodimeric protein having an apparent molecular of 220 kD as shown by non-reducing SDS-polyacrylamide gel electrophoresis.

Three regions of the P-selectin ligand protein of SEQ ID NO:1 are: an extracellular domain (from about amino acid 21 to 310 of SEQ ID NO:1), a transmembrane domain (from about amino acid 311 to 332 of SEQ ID NO:1), and an intracellular, cytoplasmic domain (from about amino acid 333 to 402 of SEQ ID NO:1). The extracellular domain contains three consensus tripeptide sites (Asn-X-Ser/Thr) of potential N-linked glycosylation beginning at Asn residues 65, 111, and 292. The extracellular domain further contains three potential sites of tyrosine sulfation at residues 46, 48, and 51. The region comprised of residues 55-267 contains a high percentage of proline, serine, and threonine including a subdomain of fifteen decameric repeats of the ten amino acid consensus sequence Ala-Thr/Met-Glu-Ala-Gln-Thr-Thr-X-Pro/Leu-Ala/Thr, wherein X can be either Pro, Ala, Gln, Glu, or Arg. Regions such as these are characteristic of highly O-glycosylated proteins.

COS or CHO cells co-transfected with a gene encoding the P-selectin ligand protein and a gene encoding an ( $\alpha$ 1,3/1,4) fucosyltransferase (hereinafter 3/4FT) are capable of binding to CHO cells expressing P-selectin on their surface, but are not capable of binding to CHO cells which do not express P-selectin on their surface. In order to bind to P-selectin, either in purified form or expressed on the surface of CHO cells, the gene encoding the P-selectin ligand protein must be co-transfected with the gene encoding a 3/4FT, since transfection of either gene in the absence of the other either abolishes or substantially reduces the P-selectin binding activity. The binding of the P-selectin ligand protein of the invention to P-selectin can be inhibited by EDTA or by a neutralizing monoclonal antibody specific for P-selectin. The binding of the P-selectin ligand protein of the invention to P-selectin is not inhibited by a non-neutralizing monoclonal antibody specific for P-selectin or by

an isotype control. These results characterize the binding specificity of the P-selectin ligand protein of the invention.

For the purposes of the present invention, a protein is defined as having "P-selectin ligand protein activity", i.e.,  
5 variably referred to herein as a "P-selectin ligand protein", or as a "P-selectin ligand glycoprotein" or simply as a "P-selectin ligand", when it binds in a calcium-dependent manner to P-selectin which is present on the surface of cells as in the CHO-P-selectin binding assay of Example 4, or to P-selectin which is  
10 affixed to another surface, for example, as the chimeric P-selectin-IgG $\gamma$ 1 protein of Example 4 is affixed to Petri dishes.

The glycosylation state of the P-selectin ligand protein of the invention was studied using a chimeric, soluble form of the P-selectin ligand protein, described in detail in Example 5(C)  
15 and designated sPSL.T7. The sPSL.T7 protein produced from COS cells co-transfected with 3/4FT is extensively modified by posttranslational glycosylation, as described in detail in Example 6(C). Thus, it is believed that both N- and O-linked oligosaccharide chains, at least some of which are sialylated,  
20 are present on the P-selectin ligand protein of the invention.

The P-selectin ligand protein of the invention may also bind to E-selectin. Conditioned medium from COS cells which have been co-transfected with the DNA encoding sPSL.T7 and with the DNA encoding 3/4FT, when coated on wells of plastic microtiter  
25 plates, causes CHO cells which express E-selectin to bind to the plates; however CHO cells which do not express E-selectin do not bind to such plates. The binding of CHO cells which express E-selectin to microtiter plates coated with conditioned medium from COS cells which have been co-transfected with the DNA encoding  
30 sPSL.T7 and with the DNA encoding 3/4FT is abolished in the presence of EDTA or of a neutralizing antibody specific for E-selectin. Conditioned medium from COS cells transfected only with the sPSL.T7 DNA does not cause binding of CHO cells which express E-selectin when coated on wells of microtiter plates.  
35 For these reasons, the P-selectin ligand protein of the invention is believed to be useful as an inhibitor of E-selectin-mediated

intercellular adhesion in addition to P-selectin-mediated intercellular adhesion.

Fragments of the P-selectin ligand protein which are capable of interacting with P-selectin or which are capable of inhibiting P-selectin-mediated intercellular adhesion are also encompassed by the present invention. Such fragments comprise amino acids 21 to 54 of SEQ ID NO:1, a region of the P-selectin ligand protein having a low frequency of serine and threonine residues; amino acids 55 to 127 of SEQ ID NO:1, having a high frequency of proline, serine, and threonine in addition to two consensus sequences for asparagine-linked glycosylation (Asn-X-Ser/Thr); another larger fragment, amino acids 128 to 267 of SEQ ID NO:1, having both a high frequency of proline, serine, and threonine and containing fifteen repeats of the following ten amino acid consensus sequence: Ala-(Thr/Met)-Glu-Ala-Gln-Thr-Thr-(Pro/Arg/Gln/Ala/Glu)-(Leu/Pro)-(Ala/Thr) (smaller fragments within this large fragment may also retain the capacity to interact with P-selectin or act as inhibitors of P-selectin-mediated intercellular adhesion); the region containing a consensus sequence for asparagine-linked glycosylation and comprising amino acids 268 to 308 of SEQ ID NO:1; the hydrophobic region of the protein represented by amino acids 309 to 333 of SEQ ID NO:1; and the amphiphilic region of the P-selectin ligand protein from amino acids 334 to 402. Additional fragments may comprise amino acid 43 to amino acid 56 of SEQ ID NO:1, with one or more sulfated tyrosines at amino acid 46, amino acid 48, and/or amino acid 51. Fragments of the P-selectin ligand protein may be in linear form or they may be cyclized using known methods, for example, as described in H.U. Saragovi, et al., Bio/Technology 10, 773-778 (1992) and in R.S. McDowell, et al., J. Amer. Chem. Soc. 114, 9245-9253 (1992), both of which are incorporated herein by reference. For the purposes of the present invention, all references to "P-selectin ligand protein" herein include fragments capable of binding to P-selectin.

Such fragments may be fused to carrier molecules such as immunoglobulins, to increase the valency of P-selectin ligand binding sites. For example, soluble forms of the P-selectin

ligand protein such as the fragment from amino acid 42 to amino acid 295 of SEQ ID NO:1 may be fused through "linker" sequences to the Fc portion of an immunoglobulin. For a bivalent form of the P-selectin ligand protein, such a fusion could be to the Fc portion of an IgG molecule as in Example 5(D) and in SEQ ID NO:6. Other immunoglobulin isotypes may also be used to generate such fusions. For example, a P-selectin ligand protein - IgM fusion would generate a decavalent form of the P-selectin ligand protein of the invention.

As detailed in the Examples below, the P-selectin ligand protein of the invention was initially obtained using an expression cloning approach (Clark et al. U.S. 4,675,285). A cDNA library was constructed from the human promyelocytic cell line HL60 (S.J. Collins, et al., Nature 270, 347-349 (1977), ATCC No. CCL 240). This library was cotransfected into COS cells with a DNA encoding a 3/4FT, and the cotransfectants were screened for binding to a chimeric molecule consisting of the extracellular portion of P-selectin and the Fc portion of a human IgG $\gamma$ 1 monoclonal antibody. Cotransfectants which bound to the chimeric P-selectin were enriched for cDNAs encoding the P-selectin ligand protein. This screening process was repeated several times to enrich the plasmid population further for cDNAs encoding the P-selectin ligand protein. In a second cloning stage, the enriched plasmid population was again cotransfected into COS cells with the 3/4FT gene and screened for binding to a fluorescently labeled CHO cell line which expressed P-selectin on the cell surface. A single cDNA clone was obtained from this approach and was designated pMT21:PL85. The pMT21:PL85 plasmid was deposited with the American Type Culture Collection on October 16, 1992 and given the accession number ATCC 69096.

One novel DNA of the present invention is set forth in SEQ ID NO:1. The DNA of the present invention may encode a variety of forms of the P-selectin ligand protein. For example, in one embodiment, the DNA sequence of the invention encodes the entire P-selectin ligand protein having the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402. In another embodiment, the DNA sequence of the invention encodes a



form of the P-selectin ligand protein which lacks the signal sequence and which is characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 21 to amino acid 402. In yet another embodiment, the DNA sequence of the invention  
5 encodes the mature P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402. Another embodiment of the DNA sequence of the invention encodes a soluble form of the P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1  
10 from amino acid 1 to amino acid 310. The DNA of the invention is also embodied in a DNA sequence encoding a soluble form of the mature P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310. The DNA of the invention  
15 is further embodied in a DNA sequence encoding a soluble form of the P-selectin ligand protein which lacks the signal sequence, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 21 to amino acid 310. The DNA of the present invention is free from association with other  
20 human DNAs and is thus characterized as an isolated DNA. As detailed above, DNAs which encode P-selectin ligand fragments which interact with P-selectin are also included in the present invention.

The expression of P-selectin ligand protein mRNA transcripts  
25 has been observed in a variety of human cell lines (HL-60, THP-1, U937) and in human monocytes and polymorphonuclear leukocytes by Northern analysis using a P-selectin ligand protein cDNA probe. In all of these cell lines, a major transcript of 2.5 kb was observed. A minor species of approximately 4 kb was observed in  
30 the HL60 and U937 cell lines and in polymorphonuclear leukocytes. In contrast, no P-selectin ligand mRNA expression was detected in the human hepatoblastoma cell line HepG2.

The P-selectin ligand protein of the invention is encoded by a single copy gene and is not part of a multi-gene family, as  
35 determined by Southern blot analysis. The genomic form of the P-selectin ligand protein of the invention contains a large intron of approximately 9 kb located at nucleotide 54 in the 5'

untranslated region. In polymorphonuclear leukocytes and monocytes, the P-selectin ligand protein of the invention is encoded by the DNA sequence set forth in SEQ ID NO:3. In this embodiment, the P-selectin ligand protein contains sixteen repeat regions. The isolated DNA of the invention is correspondingly also embodied in the DNA sequence set forth in SEQ ID NO:3 and is contained on plasmid pPL85R16 which was deposited with the American Type Culture Collection on October 22, 1993 and given the Accession Number ATCC \_\_\_\_\_.

The invention also encompasses allelic variations of the isolated DNA as set forth in SEQ ID NO:1 or of the isolated DNA as set forth in SEQ ID NO:3, that is, naturally-occurring alternative forms of the isolated DNA of SEQ ID NO: 1 or SEQ ID NO:3 which also encode proteins having P-selectin ligand activity. Also included in the invention are isolated DNAs which hybridize to the DNA set forth in SEQ ID NO:1 or to the DNA set forth in SEQ ID NO:3 under stringent (e.g. 4xSSC at 65°C or 50% formamide and 4xSSC at 42°C), or relaxed (4xSSC at 50°C or 30-40% formamide at 42°C) conditions, and which have P-selectin ligand protein activity. Isolated DNA sequences which encode the P-selectin ligand protein but which differ from the DNA set forth in SEQ ID NO:1 or from the DNA set forth in SEQ ID NO:3 by virtue of the degeneracy of the genetic code and which have P-selectin ligand protein activity are also encompassed by the present invention. Variations in the DNA as set forth in SEQ ID NO:1 or in the DNA as set forth in SEQ ID NO:3 which are caused by point mutations or by induced modifications which enhance the P-selectin ligand activity, half-life or production level are also included in the invention. For the purposes of the present invention all references herein to the "DNA of SEQ ID NO:1" include, in addition to the specific DNA sequence set forth in SEQ ID NO:1, DNA sequences encoding the mature P-selectin ligand protein of SEQ ID NO:1; DNA sequences encoding fragments of the P-selectin ligand protein of SEQ ID NO:1 which are capable of binding to P-selectin; DNA sequences encoding soluble forms of the P-selectin ligand protein of SEQ ID NO:1; allelic variations of the DNA sequence of SEQ ID NO:1; DNAs which hybridize to the

DNA sequence of SEQ ID NO:1 and which encode proteins having P-selectin ligand protein activity; DNAs which differ from the DNA of SEQ ID NO:1 by virtue of degeneracy of the genetic code; and the variations of the DNA sequence of SEQ ID NO:1 set forth above. Similarly, all references to the "DNA of SEQ ID NO:3" include in addition to the specific DNA sequence set forth in SEQ ID NO:3, DNA sequences encoding the mature P-selectin ligand protein of SEQ ID NO:3; DNA sequences encoding fragments of the P-selectin ligand protein of SEQ ID NO:3 which are capable of binding to P-selectin; DNA sequences encoding soluble forms of the P-selectin ligand protein of SEQ ID NO:3; allelic variations of the DNA sequence of SEQ ID NO:3; DNAs which hybridize to the DNA sequence of SEQ ID NO:3 and which encode proteins having P-selectin ligand protein activity; DNAs which differ from the DNA of SEQ ID NO:3 by virtue of degeneracy of the genetic code; and the variations of the DNA sequence of SEQ ID NO:3 set forth above.

A DNA encoding a soluble form of the P-selectin ligand protein may be prepared by expression of a modified DNA in which the regions encoding the transmembrane and cytoplasmic domains of the P-selectin ligand protein are deleted and/or a stop codon is introduced 3' to the codon for the amino acid at the carboxy terminus of the extracellular domain. For example, hydrophobicity analysis predicts that the P-selectin ligand protein set forth in SEQ ID NO:1 has a transmembrane domain comprised of amino acids 311 to 332 of SEQ ID NO:1 and a cytoplasmic domain comprised of amino acids 333 to 402 of SEQ ID NO:1. A modified DNA as described above may be made by standard molecular biology techniques, including site-directed mutagenesis methods which are known in the art or by the polymerase chain reaction using appropriate oligonucleotide primers. Methods for producing several DNAs encoding various soluble P-selectin ligand proteins are set forth in Example 5.

The isolated DNA of the invention may be operably linked to an expression control sequence such as the pMT2 or pED expression vectors disclosed in Kaufman et al., Nucleic Acids Res. 19, 4485-4490 (1991), in order to produce the P-selectin ligand

recombinantly. Many suitable expression control sequences are known in the art. General methods of expressing recombinant proteins are also known and are exemplified in R. Kaufman, Methods in Enzymology 185, 537-566 (1990). As defined herein  
5 "operably linked" means enzymatically or chemically ligated to form a covalent bond between the isolated DNA of the invention and the expression control sequence, in such a way that the P-selectin ligand protein is expressed by a host cell which has been transformed (transfected) with the ligated DNA/expression  
10 control sequence.

Several endoproteolytic enzymes are known which cleave precursor peptides at the carboxyl side of paired amino acid sequences (e.g., -Lys-Arg- and -Arg-Arg-) to yield mature proteins. Such enzymes are generally known as paired basic amino  
15 acid converting enzymes or PACE, and their use in recombinant production of mature peptides is extensively disclosed in WO 92/09698 and U.S. Application Serial No. 07/885,972, both of which are incorporated herein by reference. The PACE family of enzymes are known to increase the efficiency of proteolytic  
20 processing of precursor polypeptides in recombinant host cells. As mentioned above, the P-selectin ligand protein of the invention contains such a PACE cleavage site.

The soluble mature P-selectin ligand protein of the present invention may be made by a host cell which contains a DNA  
25 sequence encoding any soluble P-selectin ligand protein as described herein and a DNA sequence encoding PACE as described in WO 92/09698 and U.S. Application Serial No. 07/885,972, incorporated herein by reference, or using the DNA sequence of SEQ ID NO:5. Such a host cell may contain the DNAs as the result  
30 of co-transformation or sequential transformation of separate expression vectors containing the soluble P-selectin ligand protein DNA and the PACE DNA, respectively. A third DNA which encodes a 3/4FT may also be co-transformed with the DNAs encoding the P-selectin ligand protein and PACE. Alternatively, the host  
35 cell may contain the DNAs as the result of transformation of a single expression vector containing both soluble P-selectin ligand protein DNA and PACE DNA. Construction of such expression

vectors is within the level of ordinary skill in molecular biology. Methods for co-transformation and transformation are also known.

Many DNA sequences encoding PACE are known. For example, a DNA encoding one form of PACE, known as furin, is disclosed in A.M.W. van den Ouweland et al., Nucl. Acids Res. 18, 664 (1990), incorporated herein by reference. A cDNA encoding a soluble form of PACE, known as PACESOL, is set forth in SEQ ID NO:5. DNAs encoding other forms of PACE also exist, and any such PACE-encoding DNA may be used to produce the soluble mature P-selectin ligand protein of the invention, so long as the PACE is capable of cleaving the P-selectin ligand protein at amino acids 38-41. Preferably, a DNA encoding a soluble form of PACE is used to produce the soluble mature P-selectin ligand protein of the present invention.

The DNAs encoding a soluble form of the P-selectin ligand protein and PACE, separately or together, may be operably linked to an expression control sequence such as those contained in the pMT2 or pED expression vectors discussed above, in order to produce the PACE-cleaved soluble P-selectin ligand recombinantly. Additional suitable expression control sequences are known in the art. Examples 3(C) and 3(D) below set forth methods for producing the soluble mature P-selectin ligand protein of the invention.

A number of types of cells may act as suitable host cells for expression of the P-selectin ligand protein. Suitable host cells are capable of attaching carbohydrate side chains characteristic of functional P-selectin ligand protein. Such capability may arise by virtue of the presence of a suitable glycosylating enzyme within the host cell, whether naturally occurring, induced by chemical mutagenesis, or through transfection of the host cell with a suitable expression plasmid containing a DNA sequence encoding the glycosylating enzyme. Host cells include, for example, monkey COS cells, Chinese Hamster Ovary (CHO) cells, human kidney 293 cells, human epidermal A431 cells, human Colo205 cells, 3T3 cells, CV-1 cells, other transformed primate cell lines, normal diploid cells, cell

strains derived from in vitro culture of primary tissue, primary explants, HeLa cells, mouse L cells, BHK, HL-60, U937, or HaK cells.

5       The P-selectin ligand protein may also be produced by operably linking the isolated DNA of the invention and one or more DNAs encoding suitable glycosylating enzymes to suitable control sequences in one or more insect expression vectors, and employing an insect expression system. Materials and methods for baculovirus/insect cell expression systems are commercially  
10       available in kit form from, e.g., Invitrogen, San Diego, California, U.S.A. (the MaxBac® kit), and such methods are well known in the art, as described in Summers and Smith, Texas Agricultural Experiment Station Bulletin No. 1555 (1987), incorporated herein by reference. Soluble forms of the P-  
15       selectin ligand protein may also be produced in insect cells using appropriate isolated DNAs as described above. A DNA encoding a form of PACE may further be co-expressed in an insect host cell to produce a PACE-cleaved form of the P-selectin ligand protein.

20       Alternatively, it may be possible to produce the P-selectin ligand protein in lower eukaryotes such as yeast or in prokaryotes such as bacteria. Potentially suitable yeast strains include *Saccharomyces cerevisiae*, *Schizosaccharomyces pombe*, *Kluyveromyces* strains, *Candida*, or any yeast strain capable of  
25       expressing heterologous proteins. Potentially suitable bacterial strains include *Escherichia coli*, *Bacillus subtilis*, *Salmonella typhimurium*, or any bacterial strain capable of expressing heterologous proteins. If the P-selectin ligand protein is made in yeast or bacteria, it is necessary to attach the appropriate  
30       carbohydrates to the appropriate sites on the protein moiety covalently, in order to obtain the glycosylated P-selectin ligand protein. Such covalent attachments may be accomplished using known chemical or enzymatic methods.

35       The P-selectin ligand protein of the invention may also be expressed as a product of transgenic animals, e.g., as a component of the milk of transgenic cows, goats, pigs, or sheep

which are characterized by somatic or germ cells containing a DNA sequence encoding the P-selectin ligand protein.

5 The P-selectin ligand protein of the invention may be prepared by culturing transformed host cells under culture conditions necessary to express a P-selectin binding glycoprotein. The resulting expressed glycoprotein may then be purified from culture medium or cell extracts. Soluble forms of the P-selectin ligand protein of the invention can be purified by affinity chromatography over Lentil lectin-Sepharose® and subsequent elution with 0.5M  $\alpha$ -methyl-mannoside. The eluted soluble P-selectin ligand protein can then be further purified and concentrated by a 0-70% ammonium sulfate precipitation step. The protein is then recovered, resuspended, and further purified by size exclusion chromatography over a TSK G4000SW<sub>XL</sub>.  
10 Alternatively, full length forms of the P-selectin ligand protein of the invention can be purified by preparing a total membrane fraction from the expressing cell and extracting the membranes with a non-ionic detergent such as Triton X-100. The detergent extract can then be passed over an affinity column comprised of immobilized P-selectin, and the P-selectin ligand protein can be eluted from the column with 10mM EDTA in a buffer containing 0.1% detergent. The material eluted from the affinity column can then be dialyzed to remove EDTA and further purified over a Lentil lectin-Sepharose® affinity column, again eluting with 0.5M  $\alpha$ -methyl-mannoside.  
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Alternatively, the P-selectin ligand protein of the invention is concentrated using a commercially available protein concentration filter, for example, an Amicon or Millipore Pellicon ultrafiltration unit. Following the concentration step, the concentrate can be applied to a purification matrix such as a gel filtration medium. Alternatively, an anion exchange resin can be employed, for example, a matrix or substrate having pendant diethylaminoethyl (DEAE) groups. The matrices can be acrylamide, agarose, dextran, cellulose or other types commonly employed in protein purification. Alternatively, a cation exchange step can be employed. Suitable cation exchangers include various insoluble matrices comprising sulfopropyl or  
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carboxymethyl groups. Sulfopropyl groups are preferred (e.g., S-Sepharose® columns). The purification of the P-selectin ligand protein from culture supernatant may also include one or more column steps over such affinity resins as concanavalin A-agarose, heparin-toyopearl® or Cibacrom blue 3GA Sepharose®; or by hydrophobic interaction chromatography using such resins as phenyl ether, butyl ether, or propyl ether; or by immunoaffinity chromatography.

Finally, one or more reverse-phase high performance liquid chromatography (RP-HPLC) steps employing hydrophobic RP-HPLC media, e.g., silica gel having pendant methyl or other aliphatic groups, can be employed to further purify the P-selectin ligand protein. Some or all of the foregoing purification steps, in various combinations, can also be employed to provide a substantially homogeneous isolated recombinant protein. The P-selectin ligand protein thus purified is substantially free of other mammalian proteins and is defined in accordance with the present invention as "isolated P-selectin ligand protein".

The isolated P-selectin ligand protein may be useful in treating conditions characterized by P-selectin mediated intercellular adhesion. Such conditions include, without limitation, myocardial infarction, bacterial or viral infection, metastatic conditions, inflammatory disorders such as arthritis, acute respiratory distress syndrome, asthma, emphysema, delayed type hypersensitivity reaction, systemic lupus erythematosus, thermal injury such as burns or frostbite, autoimmune thyroiditis, experimental allergic encephalomyelitis, multiple sclerosis, multiple organ injury syndrome secondary to trauma, diabetes, Reynaud's syndrome, neutrophilic dermatosis (Sweet's syndrome), inflammatory bowel disease, Grave's disease, glomerulonephritis, gingivitis, periodontitis, hemolytic uremic syndrome, ulcerative colitis, Crohn's disease, necrotizing enterocolitis, granulocyte transfusion associated syndrome, cytokine-induced toxicity, and the like. The isolated P-selectin ligand protein may also be useful in organ transplantation, both to prepare organs for transplantation and to quell organ transplant rejection. The isolated P-selectin ligand protein may



be used to treat hemodialysis and leukophoresis patients. Additionally, the isolated P-selectin ligand protein may be used as an antimetastatic agent. The isolated P-selectin ligand protein may be used itself as an inhibitor of P-selectin-mediated intercellular adhesion or to design inhibitors of P-selectin-mediated intercellular adhesion. The present invention encompasses both pharmaceutical compositions containing isolated P-selectin ligand protein and therapeutic methods of treatment or use which employ the isolated P-selectin ligand protein.

10       The isolated P-selectin ligand protein, purified from cells or recombinantly produced, may be used as a pharmaceutical composition when combined with a pharmaceutically acceptable carrier. Such a composition may contain, in addition to the P-selectin ligand protein and carrier, diluents, fillers, salts, 15 buffers, stabilizers, solubilizers, and other materials well known in the art. The term "pharmaceutically acceptable" means a non-toxic material that does not interfere with the effectiveness of the biological activity of the active ingredient(s). The characteristics of the carrier will depend 20 on the route of administration. The pharmaceutical composition of the invention may also contain cytokines, lymphokines, or other hematopoietic factors such as M-CSF, GM-CSF, IL-1, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12, G-CSF, Meg-CSF, stem cell factor, and erythropoietin. The 25 pharmaceutical composition may contain thrombolytic or anti-thrombotic factors such as plasminogen activator and Factor VIII. The pharmaceutical composition may further contain other anti-inflammatory agents. Such additional factors and/or agents may be included in the pharmaceutical composition to produce a 30 synergistic effect with the isolated P-selectin ligand protein, or to minimize side effects caused by the isolated P-selectin ligand protein. Conversely, the isolated P-selectin ligand protein may be included in formulations of the particular cytokine, lymphokine, other hematopoietic factor, thrombolytic 35 or anti-thrombotic factor, or anti-inflammatory agent to minimize side effects of the cytokine, lymphokine, other hematopoietic

factor, thrombolytic or anti-thrombotic factor, or anti-inflammatory agent.

5 The pharmaceutical composition of the invention may be in the form of a liposome in which the isolated P-selectin ligand protein is combined, in addition to other pharmaceutically acceptable carriers, with amphipathic agents such as lipids which exist in aggregated form as micelles, insoluble monolayers, liquid crystals, or lamellar layers which in aqueous solution. Suitable lipids for liposomal formulation include, without  
10 limitation, monoglycerides, diglycerides, sulfatides, lysolecithin, phospholipids, saponin, bile acids, and the like. Preparation of such liposomal formulations is within the level of skill in the art, as disclosed, for example, in U.S. Patent No. 4,235,871; U.S. Patent No. 4,501,728; U.S. Patent No. 4,837,028; and U.S. Patent No. 4,737,323, all of which are  
15 incorporated herein by reference.

As used herein, the term "therapeutically effective amount" means the total amount of each active component of the pharmaceutical composition or method that is sufficient to show  
20 a meaningful patient benefit, i.e., healing of chronic conditions characterized by P-selectin-mediated cellular adhesion or increase in rate of healing of such conditions. When applied to an individual active ingredient, administered alone, the term refers to that ingredient alone. When applied to a combination,  
25 the term refers to combined amounts of the active ingredients that result in the therapeutic effect, whether administered in combination, serially or simultaneously.

In practicing the method of treatment or use of the present invention, a therapeutically effective amount of isolated P-selectin ligand protein is administered to a mammal having a P-selectin-mediated disease state. The isolated P-selectin ligand protein may be administered in accordance with the method of the invention either alone or in combination with other therapies such as treatments employing cytokines, lymphokines or other  
30 hematopoietic factors. When co-administered with one or more cytokines, lymphokines or other hematopoietic factors, the isolated P-selectin ligand protein may be administered either  
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simultaneously with the cytokine(s), lymphokine(s), other hematopoietic factor(s), thrombolytic or anti-thrombotic factors, or sequentially. If administered sequentially, the attending physician will decide on the appropriate sequence of administering the isolated P-selectin ligand protein in combination with cytokine(s), lymphokine(s), other hematopoietic factor(s), thrombolytic or anti-thrombotic factors.

Administration of the isolated P-selectin ligand protein used in the pharmaceutical composition or to practice the method of the present invention can be carried out in a variety of conventional ways, such as oral ingestion, inhalation, or cutaneous, subcutaneous, or intravenous injection. Intravenous administration to the patient is preferred.

When a therapeutically effective amount of isolated P-selectin ligand protein is administered orally, the isolated P-selectin ligand protein will be in the form of a tablet, capsule, powder, solution or elixir. When administered in tablet form, the pharmaceutical composition of the invention may additionally contain a solid carrier such as a gelatin or an adjuvant. The tablet, capsule, and powder contain from about 5 to 95% isolated P-selectin ligand protein, and preferably from about 25 to 90% isolated P-selectin ligand protein. When administered in liquid form, a liquid carrier such as water, petroleum, oils of animal or plant origin such as peanut oil, mineral oil, soybean oil, or sesame oil, or synthetic oils may be added. The liquid form of the pharmaceutical composition may further contain physiological saline solution, dextrose or other saccharide solution, or glycols such as ethylene glycol, propylene glycol or polyethylene glycol. When administered in liquid form, the pharmaceutical composition contains from about 0.5 to 90% by weight of the isolated P-selectin ligand protein and preferably from about 1 to 50% isolated P-selectin ligand protein.

When a therapeutically effective amount of isolated P-selectin ligand protein is administered by intravenous, cutaneous or subcutaneous injection, the isolated P-selectin ligand protein will be in the form of a pyrogen-free, parenterally acceptable aqueous solution. The preparation of such parenterally

acceptable protein solutions, having due regard to pH, isotonicity, stability, and the like, is within the skill in the art. A preferred pharmaceutical composition for intravenous, cutaneous, or subcutaneous injection should contain, in addition  
5 to the isolated P-selectin ligand protein an isotonic vehicle such as Sodium Chloride Injection, Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection, Lactated Ringer's Injection, or other vehicle as known in the art. The pharmaceutical composition of the present invention may also  
10 contain stabilizers, preservatives, buffers, antioxidants, or other additive known to those of skill in the art.

The amount of isolated P-selectin ligand protein in the pharmaceutical composition of the present invention will depend upon the nature and severity of the condition being treated, and  
15 on the nature of prior treatments which the patient has undergone. Ultimately, the attending physician will decide the amount of isolated P-selectin ligand protein with which to treat each individual patient. Initially, the attending physician will administer low doses of the isolated P-selectin ligand protein and observe the patient's response. Larger doses of isolated P-  
20 selectin ligand protein may be administered until the optimal therapeutic effect is obtained for the patient, and at that point the dosage is not increased further. It is contemplated that the various pharmaceutical compositions used to practice the method  
25 of the present invention should contain about 0.1  $\mu$ g to about 100 mg of isolated P-selectin ligand protein per kg body weight.

The duration of intravenous therapy using the pharmaceutical composition of the present invention will vary, depending on the severity of the disease being treated and the condition and  
30 potential idiosyncratic response of each individual patient. It is contemplated that the duration of each application of the isolated P-selectin ligand protein will be in the range of 12 to 24 hours of continuous intravenous administration. Ultimately the attending physician will decide on the appropriate duration  
35 of intravenous therapy using the pharmaceutical composition of the present invention.

The isolated P-selectin ligand protein of the invention may also be used to immunize animals to obtain polyclonal and monoclonal antibodies which specifically react with the P-selectin ligand protein and which may inhibit P-selectin-mediated cellular adhesion. Such antibodies may be obtained using the entire P-selectin ligand protein as an immunogen, or by using fragments of the P-selectin ligand protein such as the soluble mature P-selectin ligand protein. Smaller fragments of the P-selectin ligand protein may also be used to immunize animals, such as the fragments set forth below: amino acid 42 to amino acid 56 of SEQ ID NO:1 and amino acid 127 to amino acid 138 of SEQ ID NO:1. An additional peptide immunogen comprises amino acid 238 to amino acid 248 of SEQ ID NO:1, with an alanine residue added to the amino terminus of the peptide. Another peptide immunogen comprises amino acid 43 to amino acid 56 of SEQ ID NO:1 having a sulfated tyrosine in any or all of positions 46, 48 or 51. The peptide immunogens additionally may contain a cysteine residue at the carboxyl terminus, and are conjugated to a hapten such as keyhole limpet hemocyanin (KLH). Additional peptide immunogens may be generated by replacing tyrosine residues with sulfated tyrosine residues. Methods for synthesizing such peptides are known in the art, for example, as in R.P. Merrifield, J.Amer.Chem.Soc. 85, 2149-2154 (1963); J.L. Krstenansky, et al., FEBS Lett. 211, 10 (1987).

Monoclonal antibodies binding to the P-selectin ligand glycoprotein or to complex carbohydrate moieties characteristic of the P-selectin ligand glycoprotein may be useful diagnostic agents for the immunodetection of inflammatory diseases and some forms of cancer. Some cancerous cells, such as small cell lung carcinomas, may express detectable levels of the P-selectin ligand protein. This abnormal expression of the P-selectin ligand protein by cancer cells may play a role in the metastasis of these cells.

Neutralizing monoclonal antibodies binding to the P-selectin ligand glycoprotein or to complex carbohydrates characteristic of the P-selectin ligand glycoprotein may also be useful therapeutics for both inflammatory diseases and also in the

treatment of some forms of cancer where abnormal expression of the P-selectin ligand protein is involved. These neutralizing monoclonal antibodies are capable of blocking the selectin mediated intercellular adherence function of the P-selectin ligand protein. By blocking the binding of the P-selectin ligand protein, the adherence of leukocytes to sites of inappropriate inflammation is either abolished or markedly reduced. In the case of cancerous cells or leukemic cells, neutralizing monoclonal antibodies against the P-selectin ligand protein may be useful in detecting and preventing the metastatic spread of the cancerous cells which may be mediated by the P-selectin ligand protein. In addition, the monoclonal antibodies bound to these cells may target the cancerous cells for antibody-dependent cell mediated cytotoxicity (ADCC), thus helping to eliminate the cancerous cells. Human antibodies which react with the P-selectin ligand protein may be produced in transgenic animals which contain human immunoglobulin encoding genes in their germ lines. Example 7 below sets forth production of a rabbit polyclonal antibody specific for P-selectin ligand protein fragments.

The P-selectin ligand protein of the invention may also be used to screen for agents which are capable of binding to the P-selectin ligand protein and thus may act as inhibitors of P-selectin mediated intercellular adhesion. Binding assays using a desired binding protein, immobilized or not, are well known in the art and may be used for this purpose using the P-selectin ligand protein of the invention. Appropriate screening assays may be cell-based, as in Example 3 below. Alternatively, purified protein based screening assays may be used to identify such agents. For example, P-selectin ligand protein may be immobilized in purified form on a carrier and binding to purified P-selectin may be measured in the presence and in the absence of potential inhibiting agents. A suitable binding assay may alternatively employ purified P-selectin immobilized on a carrier, with a soluble form of the P-selectin ligand protein of the invention.

Any P-selectin ligand protein may be used in the screening assays described above. For example, the full-length P-selectin ligand protein set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402 may be used to screen for inhibitors; or the  
5 mature P-selectin ligand protein set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402 may be used to screen for inhibitors, or the soluble mature P-selectin ligand protein set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310 may be used to screen for inhibitors. Alternatively, the P-selectin  
10 ligand protein of SEQ ID NO:3 from amino acid 1 to amino acid 412, or a mature form of the P-selectin ligand protein as set forth in SEQ ID NO:3 from amino acid 42 to amino acid 412, or a soluble mature form of the P-selectin ligand protein set forth in SEQ ID NO:3 from amino acid 42 to amino acid 320 may be used  
15 to screen for inhibitors of intercellular adhesion in accordance with the present invention.

In such a screening assay, a first binding mixture is formed by combining P-selectin and the P-selectin ligand protein, and the amount of binding in the first binding mixture ( $B_0$ ) is  
20 measured. A second binding mixture is also formed by combining P-selectin, the P-selectin ligand protein, and the compound or agent to be screened, and the amount of binding in the second binding mixture (B) is measured. The amounts of binding in the first and second binding mixtures are compared, for example, by  
25 performing a  $B/B_0$  calculation. A compound or agent is considered to be capable of inhibiting P-selectin mediated intercellular adhesion if a decrease in binding in the second binding mixture as compared to the first binding mixture is observed. The formulation and optimization of binding mixtures is within the  
30 level of skill in the art, such binding mixtures may also contain buffers and salts necessary to enhance or to optimize binding, and additional control assays may be included in the screening assay of the invention.

Compounds found to reduce by at least about 10%, preferably  
35 greater than about 50% or more of the binding activity of P-selectin ligand protein to P-selectin may thus be identified and then secondarily screened in other selectin binding assays,

including assays of binding to E-selectin and to L-selectin and *in vivo* assays. By these means compounds having inhibitory activity for selectin-mediated intercellular adhesion which may be suitable as anti-inflammatory agents may be identified.



**EXAMPLE 1****CLONING OF THE P-SELECTIN LIGAND PROTEIN GENE****A. Construction of the HL60 cDNA library**

An HL60 cDNA library was constructed for expression cloning the P-selectin ligand. PolyA<sup>+</sup> RNA was isolated from total RNA from the human promyelocytic cell line HL60 (S.J. Collins, et al., *supra*) using a Fast Track mRNA Isolation Kit (Invitrogen; San Diego, CA). Double stranded cDNA was synthesized from the polyA<sup>+</sup> RNA fraction and blunt-end ligated with EcoRI adaptors (5'-AATTCGTCGACTCTAGAG-3', 5'-CTCTAGAGTCGACGG-3'). The cDNA was ligated into the expression vector pMT21 (R. Kaufman et al., J. Mol. Cell. Biol. 9, 946-958 (1989) that had been incubated sequentially with EcoRI endonuclease and calf intestinal alkaline phosphatase and gel purified. The ligation product was electroporated in 2  $\mu$ l aliquots into competent *E. coli* DH5 $\alpha$  cells and grown in 1 ml of SOB medium (J. Sambrook et al., Molecular Cloning: A Laboratory Manual, New York, Cold Spring Harbor Laboratory Press, p1.90 (1989)) which has been supplemented with 10 mM MgCl<sub>2</sub>, 10 mM MgSO<sub>4</sub>, and 2 % glycerol for one hour at 37°C. In order to divide the library into smaller subsets, an aliquot from each ml of bacterial suspension was plated onto agar plates in the presence of ampicillin, and the number of colonies per ml was calculated. Assuming that each colony represented one cDNA clone, 600,000 clones were generated and divided into subsets of approximately 16,000 clones per pool. Each of the 38 pools were grown overnight in L-broth in the presence of ampicillin and the plasmids were purified over a CsCl gradient.

**B. Screening for the P-selectin ligand protein gene**

In the first stage, the LEC- $\gamma$ 1 binding assay of Example 4(A) was utilized to pan the HL60 cDNA library and thereby to enrich for the plasmid of interest. Six  $\mu$ g of each HL60 cDNA library pool was co-transfected with 2  $\mu$ g of  $\alpha$  3/4FT gene (Example 2) into COS cells. Approximately 45 hours post-transfection, the COS cells were lifted from the plates by incubating the cells in

1mM EGTA for 15 min. at 37°C, followed by scraping with cell lifters. The cells were washed twice in Hanks buffered saline solution containing 1mM calcium (HBSS). The cells were resuspended in 4 ml of HBSS. The resuspended transfected COS  
5 cells were screened using the LEC-γ1 binding assay described in Example 4(A).

The plasmids from adherent COS cells were recovered from a Hirts extract [B. Hirts, J. Mol. Biol., 26, 365-369 (1967)] and then electroporated into E. coli DH5α cells for amplification.  
10 The enriched population of plasmids was purified over a CsCl gradient and re-transfected along with the 3/4FT gene (Example 2) into COS cells. The transfection, screening, and plasmid amplification process was repeated for a total of three times before a pool that bound to the LEC-γ1-coated plates was visually  
15 detected. The positive plasmid pool was subsequently broken down into subsets. This involved electroporating the Hirts extract from the positive pool into E. coli DH5α cells and quantitating colonies per ml as described above. Various pool sizes were produced by plating out a predetermined number of colonies on  
20 agar plates in the presence of ampicillin. Duplicate plates were prepared by performing nitrocellulose lifts and storing the filters on new agar plates. The duplicate plates served as reference plates for selecting individual or groups of colonies from any pool identified as being positive.

25 In the second stage of cloning, COS cells were co-transfected with the sublibrary pools and the 3/4FT gene by the same procedure used in the initial steps of screening. Forty-eight hours post-transfection, the transfected cells were screened using the fluorescent CHO:P-selectin assay of Example  
30 4(B). Positive pools were further subdivided, as described above, until finally individual colonies were screened and positive clones identified. Using this method, a single positive clone, pMT21:PL85, was found to encode the P-selectin ligand protein. The DNA sequence of the P-selectin ligand contained in  
35 pMT21:PL85 is set forth in SEQ ID NO:1, and the binding characteristics of the P-selectin ligand protein encoded by pMT21:PL85 are set forth in Example 4(C) below.

EXAMPLE 2CLONING THE  $\alpha$  1,3/1,4 FUCOSYLTRANSFERASE GENE

5 The  $\alpha$  1,3/1,4 fucosyltransferase gene (3/4FT) was cloned from total human genomic DNA (Clontech Laboratories) by means of PCR. The sense oligonucleotide primer contained an XbaI site and the 5' terminus of the gene (5' - TAGCATACGCTCTAGAGCATGGATCCCCTGGGTGCA GCCAAGC-3'), and the antisense oligonucleotide primer contained  
10 an EcoRI site and the 3' terminus of the gene (5' - CCGGAATTCTCAGGTGAA CCAAGCCGC-3'). The PCR product was sequentially digested with XbaI and EcoRI and purified by standard gel purification methods. This gene was then ligated with vector pMT3Sv2ADA (R. Kaufman,  
15 Methods in Enzymology, *supra*) that had also been sequentially digested with XbaI and EcoRI and purified by standard gel purification methods. Competent HB101 cells (Biorad) were transformed with this ligation product and then plated on agar plates in the presence of ampicillin. Nitrocellulose filter  
20 lifts of ampicillin-resistant transformants were probed with a radiolabeled oligonucleotide (5'-AAGTATCTGTCCAGGGCTTCCAGGT-3') complementary to the nucleotide region 506-530 in the middle of the gene (J. Sambrook et al., *supra*).

Plasmid DNA minipreps were prepared from twelve positive  
25 clones. The purified DNA was then digested with EcoRI and XbaI to identify the correct clone with the proper size insert. This clone (pEA.3/4FT) was then grown up large scale and the DNA isolated by CsCl density gradient banding (J. Sambrook et al., *supra*). DNA sequencing confirmed the identity of the 3/4FT gene.  
30 The functionality of the gene was assessed in a cell-cell binding assay as follows. COS-1 monkey cells [(clone M6; M. Horwitz et al., Mol. Appl. Genet., 2:147-149, (1983))] were transfected with 3/4FT using DEAE dextran followed by DMSO shock treatment and chloroquine incubation [L. Sompeyrac and K. Dana, Proc. Natl.  
35 Acad. Sci., 78:7575-7578 (1981); M. Lopata et al., Nucleic Acids Res., 12:5707-5717, (1984); H. Luthman and G. Magnuson, Nucleic Acids Res., 11:1295-1308, (1983)]. The transfected COS cells

were suspended and quantitated for binding to a CHO line expressing E-selectin [G. Larsen et al., J. Biol. Chem. 267:11104-11110, (1992)]. This assay confirmed that the COS cells transfected with 3/4FT can express the sialylated Lewis<sup>x</sup> epitope on the cell surface.

### EXAMPLE 3

#### EXPRESSION OF THE P-SELECTIN LIGAND PROTEIN

10

##### A. Expression of the P-selectin Ligand in LEC11 cells

Functional P-selectin ligand was expressed in the SLe<sup>x</sup>-positive Chinese hamster ovary (CHO) cell line LEC11 (Campbell, C. and Stanley, P. Cell 35:303-309 (1983) as follows: approximately 8 µg of plasmid containing the P-selectin ligand gene (pMT21:PL85, Example 1) was transfected into LEC11 cells. At 68 hours post-transfection, the cells were treated with 2.5 mM sodium butyrate for 4 hours. The cells were observed to induce P-selectin adhesion, as determined using the 6-CFD labeled CHO:P-selectin cell binding assay (described in Example 4, section B). In contrast, neither LEC11 cells alone nor LEC11 cells transfected with a control plasmid induced P-selectin adhesion.

##### B. Expression of Soluble P-Selectin Ligand in COS cells

COS cells were transfected with 8 µg pED.sPSL.T7 (see Example 5C) and 4 µg pEA.3/4 FT plasmid of Example 2, 8 µg pED.sPSL.T7 alone, or 8 µg plasmid vector (pMT21) and 4 µg pEA.3/4 FT gene. Forty-five hr post-transfection, the cells were rinsed twice in PBS and incubated overnight at 37°C in serum-free DMEM minus phenol red (JRH Biosciences) supplemented with 2 mM L-glutamine, 100 U/ml penicillin and 100 µg/ml streptomycin. Phenylmethylsulfonyl fluoride, aprotinin and NaN<sub>3</sub> were added to final concentrations of 1mM, 2 µg/ml and 0.02%, respectively, and the conditioned medium was centrifuged to remove all debris.

For immunoprecipitation experiments, the labeled soluble P-selectin ligand protein was produced by co-transfecting COS cells

with pED.sPSL.T7 and pEA.3/4 FT. At forty-five hr post-transfection, the COS cells were labeled with 250  $\mu$ Ci/ml  $^{35}$ S methionine (NEN) for 5 hours and the medium was collected. Expression of sPSL.T7 protein was confirmed by immunoprecipitation with anti-T7 antibodies.

**C. Expression of PACE-cleaved P-selectin ligand in COS Cells**

COS cells were co-transfected with the pED.sPSL.T7 plasmid of Example 5(C), the pEA.3/4FT cDNA of Example 2, and a plasmid containing the PACE cDNA as set forth in SEQ ID NO:5. A parallel control co-transfection was done using only the pED.sPSL.T7 plasmid and the pEA.3/4FT plasmid. After 45 hours, conditioned medium from these transfected COS cells was coated onto plastic dishes and binding to CHO:P-selectin cells (Example 4) was determined. An approximately two-fold increase in bound CHO:P-selectin cells was observed for dishes coated with medium containing the P-selectin ligand co-expressed with PACE, as compared with medium containing P-selectin ligand which had not been co-expressed with PACE. Amino acid sequencing of the N-terminus of purified sPSL.T7 protein from the PACE co-transfection showed that all of the ligand had been cleaved at the PACE consensus site (amino acids 38-41 of SEQ ID NO:1). Radiolabeling of co-transfected COS cells with  $^{35}$ S-methionine and subsequent SDS-polyacrylamide gel electrophoresis and autoradiography showed that comparable quantities of the P-selectin ligand had been secreted in both co-transfections.

**D. Expression of the P-selectin Ligand Protein in CHO Cells**

A full-length form (amino acids 1-402) of the P-selectin ligand protein was expressed in the CHO(DUKX) cell line (Urlaub & Chasin, Proc. Natl. Acad. Sci. USA 77, 4216-4220 (1980)) as follows: approximately 25  $\mu$ g of the pMT21:PL85 plasmid and approximately 8  $\mu$ g of the pED.3/4FT (produced by restriction of pEA.3/4FT with EcoRI and XbaI and insertion of the resulting fragment into the pED plasmid) were co-transfected into CHO(DUKX) cells using the calcium phosphate method. Transfectants were selected for resistance to methotrexate. After two weeks,

individual colonies were screened for SLe<sup>x</sup> expression by using a conjugate of an anti SLe<sup>x</sup> antibody (CSLEX-1, U.S. 4,752,569) and sheep red blood cells (sRBC) prepared by the chromic chloride method (Goding, J. W., J. Immunol. Methods 10:61-66 (1976) as follows: sRBC were washed with 0.15M NaCl until the wash became clear and then a 50% suspension of sRBC was prepared in 0.15M NaCl. One ml of 0.01% chromic chloride solution was added dropwise while vortexing to 0.2 ml of a sRBC suspension containing 50 µg of CSLEX-1. After incubating at 37°C for 30 minutes, 10 ml of phosphate buffered saline (PBS) solution was added to the reaction. The conjugate was washed once before resuspending into 10 ml of PBS. The plates containing transfectants were washed with PBS and then 3 ml of PBS and one ml of the sRBC/CSLEX-1 conjugate was added to each plate. Positive colonies were red on a transilluminator and were picked into alpha medium with 10% fetal bovine serum. After two weeks, colonies were subjected to stepwise amplification using methotrexate at concentrations of 2, 10, 25, 100, 250 nM. The stable cell line obtained was designated CD-PSGL-1 (R3.4). Expression of the P-selectin ligand protein was confirmed by immunoprecipitation studies using the polyclonal anti-P-selectin ligand protein antibody of Example 7(A). The functionality of the P-selectin ligand protein produced by the CD-PSGL-1 (R3.4) cell line was tested by assaying the transfectants for binding to LEC-γ1 as in Example 4(A).

The sPSL.T7 protein was expressed in a stable CHO-PACE line which was already expressing the cDNA encoding PACE as set forth in SEQ ID NO:5 under adenosine deaminase selection (Kaufman, et al., PNAS (USA) 83:3136-3140 (1986)). The psPSL.T7 (25 µg) and pED.3/4FT (8 µg) plasmids were cotransfected into CHO-PACE cells using the calcium phosphate method. Transfectants were selected for resistance to methotrexate, and individual colonies which bound to the sRBC/CSLEX-1 conjugate were picked. After two weeks in culture, the colonies were subjected to stepwise amplification as described above. The stable cell line obtained was designated CP/PSL-T7 (R4.1). Expression of sPSL.T7 protein was confirmed by standard immunoprecipitation methods using either a T7

specific monoclonal antibody or the LEC- $\gamma$ 1 chimera of Example 4(A). In a similar fashion, a stable cell line expressing the mature full length form (amino acids 42-402) of the P-selectin ligand protein was obtained by co-transfection of pMT21:PL85 and pED.3/4FT into the CHO-PACE line.

Stable cell lines expressing the sPSL.Q protein of Example 5(B) and the sPSL.Fc protein of Example 5(D) were constructed as follows: plasmids pED.sPSL.Q (25  $\mu$ g) or pED.sPSL.Fc (25  $\mu$ g) were cotransfected with approximately 25  $\mu$ g of the pED.3/4FT plasmid described above and approximately 20  $\mu$ g of a plasmid containing the PACE cDNA as set forth in SEQ ID NO:5) as well as the neomycin resistance gene into CHO(DUKX) cells using the calcium phosphate method. Transfectants were selected for resistance to methotrexate and the G418 antibiotic. Approximately two weeks later, individual colonies were screened for SLe<sup>x</sup> expression using SRBC/CSLEX-1 conjugate binding. The positive colonies were picked in G418 medium at 1 mg/ml concentration. After 2-3 weeks in culture, cells were amplified with methotrexate in a stepwise selection. The stable cell lines obtained were designated CD-sPSL.Q (R8.2) and CD-sPSL.Fc (R8.1), respectively. The expression of sPSL.Q and sPSL.Fc protein was confirmed by standard immunoprecipitation method using the anti P-selectin ligand protein polyclonal antibody of Example 7(A).

#### EXAMPLE 4

##### ASSAYS OF P-SELECTIN-MEDIATED INTERCELLULAR ADHESION

###### A. LEC- $\gamma$ 1 Binding Assay

A DNA encoding a chimeric form of P-selectin conjugated to the Fc portion of a human IgG $\gamma$ 1 (LEC- $\gamma$ 1) was constructed using known methods (Aruffo et al. Cell 67, 35-44 (1991)), and stably transfected into dhfr<sup>r</sup> CHO cells (CHO DUKX) for high level production of the chimeric LEC- $\gamma$ 1 protein, which was purified for use in the binding assay set forth below.

Petri dishes were coated first with a polyclonal anti-human IgG $\gamma$ 1 Fc antibody and then with LEC- $\gamma$ 1. This method orients the

LEC- $\gamma$ 1 construct such that the P-selectin portion of the chimeric molecule is presented on the surface of the plates. Adhesion of HL60 cells to the oriented LEC- $\gamma$ 1 was quantitated in the presence and absence of calcium. HL60 adhesion was shown to be calcium  
5 dependent, confirming that the chimeric molecule had retained functional binding of P-selectin to its ligand on HL60 cells. The binding of HL60 cells to oriented LEC- $\gamma$ 1 was also shown to be blocked by a neutralizing monoclonal antibody to P-selectin, demonstrating the specificity of P-selectin binding.

10

**B. Fluorescent CHO-P-selectin Binding Assay**

The assay employed a fluorescently labeled CHO:P-selectin cell line (Larsen et al., J. Biol. Chem. 267, 11104-11110 (1992)) that can bind to and form clusters on the surface of COS cells  
15 that are co-transfected with the P-selectin ligand gene and the 3/4 FT gene. The CHO:P-selectin cells were suspended at  $1.5 \times 10^6$  cells/ml in 1% fetal bovine serum in DME medium and labeled by adding 6-carboxyfluorescein diacetate (6-CFD) to a final concentration of 100 ug/ml. After incubation at 37°C for 15  
20 minutes, the cells were washed in medium and resuspended at  $1 \times 10^5$  cells/ml. Five ml of the labeled cells were added to each washed COS transfectant-containing plate to be assayed and incubated at room temperature for 10 minutes. Nonadherent cells were removed by four washes with medium. The plates were then  
25 scanned by fluorescence microscopy for rosettes of adherent CHO:P-selectin cells.

**C. Quantitative adhesion assay using radioactively labeled CHO:P-selectin cells**

COS cells were co-transfected with the pMT21:PL85 plasmid of Example 1 and the pEA.3/4FT plasmid of Example 2 by the same  
30 procedure used in the initial stages of screening. As controls, COS cells were transfected with pMT21:PL85 alone, or with pEA.3/4FT alone, or with a similar plasmid containing no insert ("mock"). 24 hours post-transfection, the transfected cells were  
35 trypsinized and distributed into Costar 6-well tissue culture plates. CHO:P-selectin cells were labeled for 16 hours with  $^3\text{H}$ -thymidine using known methods and preincubated at  $0.5 \times 10^6$



cells/ml for 30 minutes at 4°C in  $\alpha$  medium containing 1% BSA (control);  $\alpha$  medium containing 1% BSA, 5 mM EDTA and 5 mM EGTA;  $\alpha$  medium containing 1% BSA and 10  $\mu$ g/ml of a neutralizing anti P-selectin monoclonal antibody; and  $\alpha$  medium containing 1% BSA and a non-neutralizing anti-P-selectin monoclonal antibody. The preincubated cells were then added to the wells containing the transfected COS cells. After a 10 minute incubation, unbound cells were removed by 4 changes of medium. The bound CHO:P-selectin cells were released by trypsinization and quantified by scintillation counting.

COS cells co-transfected with P-selectin ligand and the 3/4FT induced approximately 5.4-fold more binding of CHO:P-selectin cells relative to COS mock cells; assay in the presence of EGTA and EDTA reduced binding to the level of the mock transfected COS cells. Likewise, incubation with neutralizing anti-P-selectin antibody also eliminated specific binding, whereas non-neutralizing antibody had no effect. In contrast, the binding of CHO:P-selectin to COS cells transfected with P-selectin ligand alone was not statistically different than binding to the mock-transfected COS in both the presence or absence of EDTA and EGTA, or anti-P-selectin antibodies. The binding of CHO:P-selectin cells to COS cells transfected with 3/4 FT alone was approximately 2-fold greater than to the mock-transfected COS, but was unaffected by the presence or absence of EDTA and EGTA.

#### EXAMPLE 5

##### CONSTRUCTION OF SOLUBLE P-SELECTIN LIGANDS

The EcoRI adaptors used to generate the cDNA library from HL60 cells in Example I contain an XbaI restriction site (TCTAGA) just 5' of the beginning of SEQ ID NO:1 as it is located in the pMT21:PL85 plasmid. In order to generate soluble forms of the PSL, the pMT21:PL85 plasmid was restricted with XbaI and with HincII (which cleaves after nucleotide 944 of SEQ ID NO:1). The approximately 950 bp fragment thus generated, containing all of the encoded extracellular segment of the ligand up to and including the codon for valine 295, was isolated and used to

generate DNAs encoding soluble forms of the P-selectin ligand protein as set forth in sections A through D below.

**A. Construction of psPSL.QC**

5       The fragment was purified and ligated into mammalian expression vector pED between the XbaI and EcoRI sites, along with double stranded synthetic oligonucleotide DNA that recreated the codons from Asn 296 to Cys 310 and introduced a novel stop codon immediately following Cys 310. The sequence of the oligos  
10       is as follows:

5'-AACTACCCAGTGGGAGCACCAGACCACATCTCTGTGAAGCAGTGCTAG

5'-AATTCTAGCACTGCTTCACAGAGATGTGGTCTGGTGCTCCCACTGGGTAGTT

The resulting plasmid was designated pED.sPSL.QC, and the protein expressed from the plasmid was designated sPSL.QC.

15

**B. Construction of psPSL.Q**

20       The fragment was purified and ligated into the pED plasmid (Kaufman et al., 1991) between the XbaI and EcoRI sites, along with the double stranded synthetic oligonucleotide DNA that recreated the codons from Asn 296 to Gln 309 and introduced a novel stop codon immediately following Gln 309. The sequence of the oligos is as follows:

5'-AACTACCCAGTGGGAGCACCAGACCACATCTCTGTGAAGCAGTAG

25       5'-AATTCTACTGCTTCACAGAGATGTGGTCTGGTGCTCCCACTGGGTAGTT

The resulting plasmid was designated pED.sPSL.Q, and the protein expressed from the plasmid was designated sPSL.Q.

**C. Construction of psPSL.T7**

30       Oligonucleotides encoding 14 amino acids including an epitope derived from the phage T7 major capsid protein were synthesized, creating a C-terminal fusion of the epitope "tag" with an additional 32 amino acids derived from the vector sequence. Two oligonucleotides having the sequences

35       5'-CTAGACCCGGGATGGCATCCATGACAGGAGGACAACAAATGGTAGGCCGTAG and

5'-AATTCTACGGCCTACCCATTTGTTGTCCTCCTGTCATGGATGCCATCCCGGGT

were duplexed and ligated with the large XbaI-EcoRI fragment of mammalian expression plasmid pED. The resulting plasmid, pED.T7 was restricted with XbaI and SmaI and ligated to the 950 bp XbaI-HincII fragment described above, resulting in plasmid pED.sPSL.T7.

The protein resulting from expression of pED.sPSL.T7 was designated sPSL.T7.

**D. Construction of Soluble P-selectin Ligand--IgGFc Chimera**

The plasmid DNA encoding a soluble, extracellular form of the P-selectin ligand protein fused to the Fc portion of human immunoglobulin IgG1 was constructed as follows: the mammalian expression vector pED.Fc contains sequences encoding the Fc region of a human IgG1 with a novel linker sequence enabling the fusion of coding sequences amino terminal to the hinge region via a unique XbaI restriction site. A three fragment ligation was performed: pED.Fc was restricted with XbaI and gel purified in linear form. The 950 bp fragment from pMT21:PL85 described above comprised the second fragment. The third fragment consisted of annealed synthetic oligonucleotide DNAs having the following sequence:

5' - CTGCGGCCGCGAGT

5' - CTAGACTGCGGCCGCGAG

The ligation products were grown as plasmid DNAs and individual clones having the correct configuration were identified by DNA sequencing. The plasmid was designated pED.PSL.Fc. The DNA coding region of the resulting soluble P-selectin ligand /Fc fusion protein is shown in SEQ ID NO:6.

**EXAMPLE 6**

**CHARACTERIZATION OF EXPRESSED P-SELECTIN LIGANDS**

**A. Binding Characterization of Full-Length P-selectin Ligand Protein Expressed on COS Cells**

Co-transfection of COS cells with the pEA.3/4FT plasmid of Example 2 and the pMT21:PL85 plasmid of Example 1 yields COS cells which specifically bind to CHO:P-selectin cells. This binding is observed only upon co-transfection of pEA.3/4FT and pMT21:PL85; use of either plasmid alone generates COS cells which

do not bind to CHO:P-selectin cells. No binding is observed between the parental CHO(DUKX) cell line which does not express P-selectin and COS cells co-transfected with pEA.3/4FT and pMT21:PL85. The binding between the co-transfected COS cells and CHO:P-selectin cells is sensitive to chelators of divalent ions such as EDTA and EGTA, consistent with the  $\text{Ca}^{++}$  dependency of P-selectin mediated cellular adhesion. A neutralizing anti-P-selectin monoclonal antibody blocked the binding between the CHO:P-selectin cells and the COS cells which had been co-transfected with pEA.3/4FT and pMT21:PL85, while a non-neutralizing anti-P-selectin monoclonal antibody had no effect on the binding. The antibody results indicate that the functional domain(s) of P-selectin are required for binding to P-selectin ligand protein expressed on the surface of COS cells.

**B. Electrophoretic Characterization of Full-Length P-selectin Ligand Expressed in COS Cells**

Detergent extracts of co-transfected COS cells were prepared as follows: 45 hours post co-transfection, approximately  $1.5 \times 10^7$  cells were suspended in 5 ml of lysis buffer (10mM Piperazine-N,N'-bis[2-ethanesulfonic acid] (PIPES) pH 7.5, 100 mM KCl, 3 mM MgCl<sub>2</sub>, 1 mM benzamidine, 0.5  $\mu\text{g}/\text{ml}$  leupeptin, 0.75  $\mu\text{g}/\text{ml}$  pepstatin, 1 mM ethylmaleimide, and 1  $\mu\text{g}/\text{ml}$  aprotinin) and lysed by sonication. Cellular debris was removed by low speed centrifugation (500 x g, 10 minutes), and a membrane fraction collected by ultracentrifugation (100,000 x g, 60 min). The high speed membrane pellet was resuspended in an extraction buffer (10 mM 3-[N-Morpholino]propanesulfonic acid] (MOPS) pH 7.5, 0.1M NaCl, 0.02% NaN<sub>3</sub>, 1% Thesit® (Sigma), 1 mM benzamidine, 0.5  $\mu\text{g}/\text{ml}$  leupeptin, 0.75  $\mu\text{g}/\text{ml}$  pepstatin, 1 mM ethylmaleimide, and 1  $\mu\text{g}/\text{ml}$  aprotinin). Samples were then subjected to SDS polyacrylamide gel electrophoresis and transfer to nitrocellulose blots as follows: an aliquot of the detergent extract was suspended in 1% SDS loading buffer and heated for 5 minutes at 100°C before loading onto an 8-16% polyacrylamide gel (reduced) or a 6% gel (non-reduced) and electrophoresed in the Laemmli buffer system. Blots were prepared using Immobilon-P® transfer membranes. The blots were immersed in 10 mM MOPS pH 7.5, 0.1M NaCl, 0.02% NaN<sub>3</sub>,

1 mM MgCl<sub>2</sub>, 1 mM CaCl<sub>2</sub>, and 10% non-fat milk overnight at 4°C. Blots were rinsed once in the above buffer, minus the milk, and incubated in blotting buffer (10 mM MOPS pH 7.5, 0.1M NaCl, 1% bovine serum albumin, 0.05% Thesit, 1 mM MgCl<sub>2</sub>, 1 mM CaCl<sub>2</sub>) for 30 minutes at room temperature.

The blots were then probed for the P-selectin ligand as follows: 50 ng of a P-selectin/Fc chimera was pre-incubated with 3 µCi of <sup>125</sup>I-Protein A in blotting buffer for 30 minutes at room temperature. Additional excipients (e.g., EDTA, EGTA, monoclonal antibodies) could be added to the pre-incubation mixture at this point to evaluate their effects on binding of the chimera to the P-selectin ligand. The pre-incubated mixture was then incubated with the blots (prepared as above) for 60 minutes at room temperature, and the blots were subsequently washed four times with the same blotting buffer (without bovine serum albumin), air dried, and autoradiographed at -70°C.

Under non-reducing conditions, two bands were observed with this technique for membrane extracts prepared from co-transfected COS cells. The major band migrated with an estimated molecular weight of approximately 220 kD, whereas the minor band migrated with a molecular weight of approximately 110 kD. Under reducing conditions, only a single band was observed with a molecular weight of approximately 110 kD, indicating that under non-reducing conditions, the P-selectin ligand exists as a homodimer. The approximate molecular weight of the reduced monomer is greater than that predicted from the deduced amino acid sequence of the cDNA clone (45 kD), indicating that the expressed protein undergoes extensive post-translational modification (see Example 6(C)). The specificity of the P-selectin/Fc chimera was confirmed by the observation that a nonspecific IgG, probe yielded no bands on the blots. Additionally, the binding of the P-selectin/Fc chimera to the blots was abolished by EDTA, EGTA, and a neutralizing anti-P-selectin monoclonal antibody. Specific bands on the blots were observed only from membrane extracts of COS cells co-transfected with the pEA.3/4FT and pMT21:PL85 plasmids. Membrane extracts from control transfections

(pEA.3/4FT or pMT21:PL85 alone) failed to yield observable bands on blots.

C. Glycosylation of P-selectin Ligand Protein

5           The presence of covalently attached carbohydrate on recombinant P-selectin ligand and its role in binding to P-selectin was determined as follows: COS cells were co-transfected with pED.sPSL.T7 of Example 5(C) and the pEA.3/4FT plasmid of Example 2. After 48 hours, the cells were pulsed with  
10 <sup>35</sup>S-methionine. 200  $\mu$ l of <sup>35</sup>S methionine-labeled sPSL.T7 conditioned medium was incubated with 5  $\mu$ g LEC- $\gamma$ 1 in the presence of 2mM CaCl<sub>2</sub> and 1 mg/ml bovine serum albumin (BSA). After rotating for 2 hours at 4°C, Protein A-Sepharose beads (Pharmacia) were added for 1 hour at 4°C, pelleted by  
15 centrifugation and washed twice in Tris buffered saline (20 mM Tris-HCl, 150 mM NaCl pH 7.5, hereinafter TBS) containing 2mM CaCl<sub>2</sub> and 1 mg/ml BSA. The pellets were then resuspended and treated with neuraminidase (*Streptococcus pneumoniae*), O-glycanase, and N-glycanase (all from Genzyme) as follows. All  
20 glycosidase digestions were done at 37°C overnight. For neuraminidase digestion, the pellet was resuspended in 50  $\mu$ l 2-(N-morpholino)-ethanesulfonic acid (MES) buffer, pH 6.5 (Calbiochem) and 0.1% SDS, heated at 95°C for 5 minutes, then pelleted. The supernatant was modified to contain 1.4% n-Octyl  
25 B-D-glucopyranoside (OGP), 10mM calcium acetate, 20 mM sodium cacodylate and 2.5 mM PMSF, final pH 7.0. Eight  $\mu$ l neuraminidase was added for a final concentration of 1 unit/ml. For neuraminidase/O-glycanase digestion, the sample was prepared as above and along with the neuraminidase, the O-glycanase was also  
30 added to a final concentration of 0.1 unit/ml. For N-glycanase digestion, the pellet was resuspended in 54  $\mu$ l MES buffer and 1% SDS, heated at 95°C for 5 minutes, then pelleted. The supernatant was modified to contain 0.2 M sodium phosphate, 3.5% OGP, and 2.5 mM PMSF, final pH 8.5. N-glycanase was added for  
35 a final concentration of 12 units/ml and incubated as above.

The effect of glycosidase treatment on sPSL.T7 was assessed in two ways. For this, each digested protein sample was divided

into two equal fractions. One fraction was precipitated with the P-selectin polyclonal antibody of Example 7(A), to show the effect of digestion on the electrophoretic mobility. The other fraction was precipitated with the LEC- $\gamma$ 1 chimera of Example 4(A), to assess the remaining P-selectin ligand binding activity after digestion. The immunoprecipitated samples were analyzed by SDS-polyacrylamide gel electrophoresis under reducing conditions and autoradiography.

In the absence of glycosidase treatment, autoradiography revealed comparable bands (with molecular weights of 110 kD) for each precipitation. When the P-selectin ligand protein was treated with neuraminidase, anti-P-selectin ligand polyclonal antibody precipitation revealed a slight decrease in mobility, consistent with removal of sialic acid residues. The amount of P-selectin ligand protein precipitated by LEC- $\gamma$ 1 was significantly reduced after neuraminidase treatment, consistent with the role of sialic acid residues in the P-selectin/P-selectin ligand interaction. When the P-selectin ligand protein was treated with both neuraminidase and O-glycanase, a substantial increase in electrophoretic mobility was observed after precipitation with the anti-P-selectin ligand polyclonal antibody, indicating that a number of O-linked oligosaccharide chains had been removed. However, removal of O-linked oligosaccharides from the P-selectin ligand protein may not have been complete, since the electrophoretic mobility did not correspond to a protein with a molecular weight of 38 kD, as would be predicted from the amino acid sequence set forth in SEQ ID NO:1. The neuraminidase/O-glycanase digested P-selectin ligand protein bound to LEC- $\gamma$ 1 very poorly, further indicating the role of oligosaccharides in the P-selectin/P-selectin ligand interaction. Treatment of the purified P-selectin ligand with N-glycanase resulted in a slight increase in electrophoretic mobility, demonstrating that some of the consensus sites for N-linked glycosylation are occupied. The amount of P-selectin ligand protein precipitated by LEC- $\gamma$ 1 was slightly reduced, indicating that N-linked glycosylation also contributes to the

P-selectin/P-selectin ligand interaction, though not as dramatically as sialylation and O-linked glycosylation.

#### EXAMPLE 7

##### POLYCLONAL ANTIBODIES SPECIFIC FOR P-SELECTIN LIGANDS

5

##### A. Polyclonal Rabbit anti-P-selectin Ligand Protein/Maltose Binding Protein Fusion Protein

The anti-P-selectin ligand polyclonal antibody was generated by immunizing rabbits with a fusion protein generated in *E. coli*. The fusion protein consisted of the amino terminal one-third of the P-selectin ligand (amino acids 1 to 110 of SEQ ID NO:1) fused in frame to the maltose binding protein (Maina, C. V. et al., Gene 74, 365-373 (1988); Riggs, P., in Current Protocols in Molecular Biology, F. M. Ausubel et al., Eds., Greene Associates/Wiley Interscience (New York, 1990) chapter 16.6). Under conditions employed herein, the fusion protein antibody recognizes the P-selectin ligand protein.

##### 20 B. Polyclonal Rabbit Anti-sPSL.T7 Protein

A soluble form of the invention (sPSL.T7; see example 5(C)) was purified to apparent homogeneity according to the following scheme: COS cells were transfected with three plasmids, one encoding each of the following: sPSL.T7 (Example 5(C)), 3/4FT (Example 2), and a soluble form of PACE (as set forth in SEQ ID NO:5). After 72 hours, the conditioned medium was collected and recombinant sPSL.T7 was purified as follows.

Conditioned medium was diluted two fold with 50 mM MOPS, 150 mM NaCl, 0.5 mM CaCl<sub>2</sub>, and 0.5 mM MnCl<sub>2</sub>, pH 7.2, and applied to a column of lentil lectin-Sepharose 4B equilibrated in the same buffer. After loading, the column was washed with the same buffer until the optical absorbance at 280 nm dropped to a stable baseline. The column was then eluted with the same buffer which had been adjusted to 0.5 M  $\alpha$ -methyl-mannoside and 0.3 M NaCl. Recombinant sPSL.T7 was collected over 5-15 column volumes of this elution buffer. The lentil lectin eluate was then subjected to a 0-70% ammonium sulfate precipitation by adding 472g of ammonium sulfate per liter of column eluate at 4°C. After



stirring for 30 minutes, the precipitate was resuspended in a minimal volume of TBS (20 mM Tris-HCl, 150 mM NaCl, pH 7.5) and applied to a TSK G4000SW<sub>XL</sub> gel filtration column equilibrated in TBS. The flow rate on the column was 0.5 ml/min and a guard  
5 column was employed. In aliquots of < 250  $\mu$ l, the resuspended ammonium sulfate pellet was injected on the column and fractions analyzed by SDS-PAGE with Western analysis. Fractions containing SPLS.T7 were pooled and then used for immunizing rabbits.

Antibodies to SPLS.T7 were generated in the standard fashion  
10 by antigen priming and subsequent boosting over a 3 month period. Specifically, primary immunization was performed by mixing 50  $\mu$ g of SPLS.T7 (denatured by mixing in 0.1% SDS and heating for 10 minutes at 100°C) with complete Freund's adjuvant and injected at five sites subcutaneously. The second (and all subsequent)  
15 boosts were performed by mixing 25  $\mu$ g of SPLS.T7 (denatured by mixing in 0.1% SDS and heating for 10 minutes at 100°C) [12.5  $\mu$ g for the third and subsequent boosts] with incomplete Freund's adjuvant and injecting at two sites subcutaneously (or later, intramuscularly) every two weeks. Test bleeds were performed  
20 every two weeks to monitor antibody titer. When the antibody titer reached a suitable level, a larger scale bleed was performed and a total serum fraction prepared. This polyclonal antibody preparation was used to inhibit the specific binding of HL60 cells to CHO:P-selectin cells in a manner similar to that  
25 described in Example 4.

This assay employed fluorescently-labeled HL60 cells (labelled with BCECFAM; 2',7'-bis-(2-carboxymethyl)-5-(and-6)-carboxyfluorescein, acetoxymethyl ester) binding to CHO cells plated on the bottom of microtiter plates. The labelled HL60  
30 cells were pre-incubated with either sera containing polyclonal antibody or with pre-immune sera for 30 minutes at 4°C. The cells were then washed and incubated with the CHO:P-selectin cells for 10 minutes. The plates were then washed and the fluorescence read with a fluorescence microtiter plate reader.  
35 Using this assay, a 1:15 dilution of the anti-SPLS.T7 polyclonal serum resulted in essentially complete inhibition of HL60 cell binding to CHO:P-selectin. Demonstrable inhibition of HL60

binding to CHO:P-selectin was still observed at antiserum dilutions of 1:150. Pre-immune serum had no effect on HL60 cell binding to CHO:P-selectin.

## SEQUENCE LISTING

## 5 (1) GENERAL INFORMATION:

- (i) APPLICANT: GENETICS INSTITUTE, INC.
- (ii) TITLE OF INVENTION: NOVEL P-SELECTIN LIGAND PROTEIN
- 10 (iii) NUMBER OF SEQUENCES: 6
- (iv) CORRESPONDENCE ADDRESS:
- 15 (A) ADDRESSEE: Legal Affairs  
(B) STREET: 87 CambridgePark Drive  
(C) CITY: Cambridge  
(D) STATE: MA  
(E) COUNTRY: USA  
(F) ZIP: 02140
- 20 (v) COMPUTER READABLE FORM:
- (A) MEDIUM TYPE: Floppy disk  
(B) COMPUTER: IBM PC compatible  
(C) OPERATING SYSTEM: PC-DOS/MS-DOS  
25 (D) SOFTWARE: PatentIn Release #1.0, Version #1.25
- (vi) CURRENT APPLICATION DATA:
- (A) APPLICATION NUMBER:  
(B) FILING DATE:  
30 (C) CLASSIFICATION:
- (vii) PRIOR APPLICATION DATA:
- (A) APPLICATION NUMBER: US 07/965,662  
(B) FILING DATE: 23-OCT-1992  
35 (C) APPLICATION NUMBER: US 08/112,608  
(D) FILING DATE: 26-AUG-1993
- (viii) ATTORNEY/AGENT INFORMATION:
- 40 (A) NAME: McDaniels, Patricia A.  
(B) REGISTRATION NUMBER: 33,194  
(C) REFERENCE/DOCKET NUMBER: GI 5213B-PCT
- (ix) TELECOMMUNICATION INFORMATION:
- 45 (A) TELEPHONE: (617) 876-1210 Ext. 8405  
(B) TELEFAX: (617) 876-5851

## (2) INFORMATION FOR SEQ ID NO:1:

- 50 (i) SEQUENCE CHARACTERISTICS:
- (A) LENGTH: 1649 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear
- 55 (ii) MOLECULE TYPE: cDNA

(vi) ORIGINAL SOURCE:  
 (A) ORGANISM: Homo sapiens  
 (G) CELL TYPE: Promyelocyte  
 (H) CELL LINE: HL60

5 (vii) IMMEDIATE SOURCE:  
 (B) CLONE: pMT21:PL85

10 (ix) FEATURE:  
 (A) NAME/KEY: 5'UTR  
 (B) LOCATION: 1..59

15 (ix) FEATURE:  
 (A) NAME/KEY: CDS  
 (B) LOCATION: 60..1268

20 (ix) FEATURE:  
 (A) NAME/KEY: 3'UTR  
 (B) LOCATION: 1269..1649

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

25	GCCACTTCTT CTGGGCCCAC GAGGCAGCTG TCCCATGCTC TGCTGAGCAC GGTGGTGCC	59
	ATG CCT CTG CAA CTC CTC CTG TTG CTG ATC CTA CTG GGC CCT GGC AAC	107
	Met Pro Leu Gln Leu Leu Leu Leu Ile Leu Leu Gly Pro Gly Asn	
	1 5 10 15	
30	AGC TTG CAG CTG TGG GAC ACC TGG GCA GAT GAA GCC GAG AAA GCC TTG	155
	Ser Leu Gln Leu Trp Asp Thr Trp Ala Asp Glu Ala Glu Lys Ala Leu	
	20 25 30	
35	GGT CCC CTG CTT GCC CGG GAC CGG AGA CAG GCC ACC GAA TAT GAG TAC	203
	Gly Pro Leu Leu Ala Arg Asp Arg Arg Gln Ala Thr Glu Tyr Glu Tyr	
	35 40 45	
40	CTA GAT TAT GAT TTC CTG CCA GAA ACG GAG CCT CCA GAA ATG CTG AGG	251
	Leu Asp Tyr Asp Phe Leu Pro Glu Thr Glu Pro Pro Glu Met Leu Arg	
	50 55 60	
45	AAC AGC ACT GAC ACC ACT CCT CTG ACT GGG CCT GGA ACC CCT GAG TCT	299
	Asn Ser Thr Asp Thr Thr Pro Leu Thr Gly Pro Gly Thr Pro Glu Ser	
	65 70 75 80	
50	ACC ACT GTG GAG CCT GCT GCA AGG CGT TCT ACT GGC CTG GAT GCA GGA	347
	Thr Thr Val Glu Pro Ala Ala Arg Arg Ser Thr Gly Leu Asp Ala Gly	
	85 90 95	
55	GGG GCA GTC ACA GAG CTG ACC ACG GAG CTG GCC AAC ATG GGG AAC CTG	395
	Gly Ala Val Thr Glu Leu Thr Thr Glu Leu Ala Asn Met Gly Asn Leu	
	100 105 110	
60	TCC ACG GAT TCA GCA GCT ATG GAG ATA CAG ACC ACT CAA CCA GCA GCC	443
	Ser Thr Asp Ser Ala Ala Met Glu Ile Gln Thr Thr Gln Pro Ala Ala	
	115 120 125	
60	ACG GAG GCA CAG ACC ACT CCA CTG GCA GCC ACA GAG GCA CAG ACA ACT	491
	Thr Glu Ala Gln Thr Thr Pro Leu Ala Ala Thr Glu Ala Gln Thr Thr	
	130 135 140	

	CGA	CTG	ACG	GCC	ACG	GAG	GCA	CAG	ACC	ACT	CCA	CTG	GCA	GCC	ACA	GAG	539
	Arg	Leu	Thr	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Thr	Glu	145
						150					155					160	
5	GCA	CAG	ACC	ACT	CCA	CCA	GCA	GCC	ACG	GAA	GCA	CAG	ACC	ACT	CAA	CCC	587
	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	165
					165					170					175		
10	ACA	GGC	CTG	GAG	GCA	CAG	ACC	ACT	GCA	CCA	GCA	GCC	ATG	GAG	GCA	CAG	635
	Thr	Gly	Leu	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	180
				180					185					190			
15	ACC	ACT	GCA	CCA	GCA	GCC	ATG	GAA	GCA	CAG	ACC	ACT	CCA	CCA	GCA	GCC	683
	Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	195
				195				200					205				
20	ATG	GAG	GCA	CAG	ACC	ACT	CAA	ACC	ACA	GCC	ATG	GAG	GCA	CAG	ACC	ACT	731
	Met	Glu	Ala	Gln	Thr	Thr	Gln	Thr	Thr	Ala	Met	Glu	Ala	Gln	Thr	Thr	210
							215					220					
25	GCA	CCA	GAA	GCC	ACG	GAG	GCA	CAG	ACC	ACT	CAA	CCC	ACA	GCC	ACG	GAG	779
	Ala	Pro	Glu	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Thr	Ala	Thr	Glu	225
						230					235					240	
30	GCA	CAG	ACC	ACT	CCA	CTG	GCA	GCC	ATG	GAG	GCC	CTG	TCC	ACA	GAA	CCC	827
	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Met	Glu	Ala	Leu	Ser	Thr	Glu	Pro	245
					245					250					255		
35	AGT	GCC	ACA	GAG	GCC	CTG	TCC	ATG	GAA	CCT	ACT	ACC	AAA	AGA	GGT	CTG	875
	Ser	Ala	Thr	Glu	Ala	Leu	Ser	Met	Glu	Pro	Thr	Thr	Lys	Arg	Gly	Leu	260
				260					265					270			
40	TTC	ATA	CCC	TTT	TCT	GTG	TCC	TCT	GTT	ACT	CAC	AAG	GGC	ATT	CCC	ATG	923
	Phe	Ile	Pro	Phe	Ser	Val	Ser	Ser	Val	Thr	His	Lys	Gly	Ile	Pro	Met	275
				275					280				285				
45	GCA	GCC	AGC	AAT	TTG	TCC	GTC	AAC	TAC	CCA	GTG	GGG	GCC	CCA	GAC	CAC	971
	Ala	Ala	Ser	Asn	Leu	Ser	Val	Asn	Tyr	Pro	Val	Gly	Ala	Pro	Asp	His	290
							295					300					
50	ATC	TCT	GTG	AAG	CAG	TGC	CTG	CTG	GCC	ATC	CTA	ATC	TTG	GCG	CTG	GTG	1019
	Ile	Ser	Val	Lys	Gln	Cys	Leu	Leu	Ala	Ile	Leu	Ile	Leu	Ala	Leu	Val	305
						310					315					320	
55	GCC	ACT	ATC	TTC	TTC	GTG	TGC	ACT	GTG	GTG	CTG	GCG	GTC	GCG	CTC	TCC	1067
	Ala	Thr	Ile	Phe	Phe	Val	Cys	Thr	Val	Val	Leu	Ala	Val	Arg	Leu	Ser	325
					325					330					335		
60	CGC	AAG	GGC	CAC	ATG	TAC	CCC	GTG	CGT	AAT	TAC	TCC	CCC	ACC	GAG	ATG	1115
	Arg	Lys	Gly	His	Met	Tyr	Pro	Val	Arg	Asn	Tyr	Ser	Pro	Thr	Glu	Met	340
				340					345					350			
65	GTC	TGC	ATC	TCA	TCC	CTG	TTG	CCT	GAT	GGG	GGT	GAG	GGG	CCC	TCT	GCC	1163
	Val	Cys	Ile	Ser	Ser	Leu	Leu	Pro	Asp	Gly	Gly	Glu	Gly	Pro	Ser	Ala	355
								360					365				
70	ACA	GCC	AAT	GGG	GGC	CTG	TCC	AAG	GCC	AAG	AGC	CCG	GGC	CTG	ACG	CCA	1211
	Thr	Ala	Asn	Gly	Gly	Leu	Ser	Lys	Ala	Lys	Ser	Pro	Gly	Leu	Thr	Pro	370
							375					380					
75	GAG	CCC	AGG	GAG	GAC	CGT	GAG	GGG	GAT	GAC	CTC	ACC	CTG	CAC	AGC	TTC	1259
	Glu	Pro	Arg	Glu	Asp	Arg	Glu	Gly	Asp	Asp	Leu	Thr	Leu	His	Ser	Phe	385
						390					395					400	
80	CTC	CCT	TAG	CTC	ACTC	TGCC	ATCT	GTG	TTT	GGCA	AGA	CCCC	ACCT	CC	ACGGG	CTCTC	1315
	Leu	Pro															

CTGGGCCACC CCTGAGTGCC CAGACCCCAA TCCACAGCTC TGGGCTTCCT CGGAGACCCC 1375  
 TGGGGATGGG GATCTTCAGG GAAGGAACTC TGGCCACCCA AACAGGACAA GAGCAGCCTG 1435  
 5 GGGCCAAGCA GACGGGCAAG TGGAGCCACC TCTTTCCTCC CTCCGCGGAT GAAGCCCAGC 1495  
 CACATTTTCAG CCGAGGTCCA AGGCAGGAGG CCATTTACTT GAGACAGATT CTCTCCTTTT 1555  
 10 TCCTGTCCCC CATCTTCTCT GGGTCCCTCT AACATCTCCC ATGGCTCTCC CCGCTTCTCC 1615  
 TGGTCACTGG AGTCTCCTCC CCATGTACCC AAGG 1649

## (2) INFORMATION FOR SEQ ID NO:2:

15

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 402 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

20

(ii) MOLECULE TYPE: protein

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

25 Met Pro Leu Gln Leu Leu Leu Leu Ile Leu Leu Gly Pro Gly Asn  
 1 5 10 15

30 Ser Leu Gln Leu Trp Asp Thr Trp Ala Asp Glu Ala Glu Lys Ala Leu  
 20 25 30

35 Gly Pro Leu Leu Ala Arg Asp Arg Arg Gln Ala Thr Glu Tyr Glu Tyr  
 35 40 45

40 Leu Asp Tyr Asp Phe Leu Pro Glu Thr Glu Pro Pro Glu Met Leu Arg  
 50 55 60

45 Asn Ser Thr Asp Thr Thr Pro Leu Thr Gly Pro Gly Thr Pro Glu Ser  
 65 70 75 80

50 Thr Thr Val Glu Pro Ala Ala Arg Arg Ser Thr Gly Leu Asp Ala Gly  
 85 90 95

55 Gly Ala Val Thr Glu Leu Thr Thr Glu Leu Ala Asn Met Gly Asn Leu  
 100 105 110

Ser Thr Asp Ser Ala Ala Met Glu Ile Gln Thr Thr Gln Pro Ala Ala  
 115 120 125

	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	
	130						135					140					
5	Arg	Leu	Thr	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Thr	Glu	
	145					150					155					160	
10	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	
					165					170						175	
15	Thr	Gly	Leu	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	
			180						185						190		
20	Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	
			195					200					205				
25	Met	Glu	Ala	Gln	Thr	Thr	Gln	Thr	Thr	Ala	Met	Glu	Ala	Gln	Thr	Thr	
	210						215					220					
30	Ala	Pro	Glu	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Thr	Ala	Thr	Glu	
	225				230					235						240	
35	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Met	Glu	Ala	Leu	Ser	Thr	Glu	Pro	
					245					250						255	
40	Ser	Ala	Thr	Glu	Ala	Leu	Ser	Met	Glu	Pro	Thr	Thr	Lys	Arg	Gly	Leu	
			260						265					270			
45	Phe	Ile	Pro	Phe	Ser	Val	Ser	Ser	Val	Thr	His	Lys	Gly	Ile	Pro	Met	
			275					280					285				
50	Ala	Ala	Ser	Asn	Leu	Ser	Val	Asn	Tyr	Pro	Val	Gly	Ala	Pro	Asp	His	
	290						295					300					
55	Ile	Ser	Val	Lys	Gln	Cys	Leu	Leu	Ala	Ile	Leu	Ile	Leu	Ala	Leu	Val	
	305				310					315						320	
60	Ala	Thr	Ile	Phe	Phe	Val	Cys	Thr	Val	Val	Leu	Ala	Val	Arg	Leu	Ser	
				325					330						335		
65	Arg	Lys	Gly	His	Met	Tyr	Pro	Val	Arg	Asn	Tyr	Ser	Pro	Thr	Glu	Met	
				340					345					350			
70	Val	Cys	Ile	Ser	Ser	Leu	Leu	Pro	Asp	Gly	Gly	Glu	Gly	Pro	Ser	Ala	

355 360 365

5 Thr Ala Asn Gly Gly Leu Ser Lys Ala Lys Ser Pro Gly Leu Thr Pro  
370 375 380

10 Glu Pro Arg Glu Asp Arg Glu Gly Asp Asp Leu Thr Leu His Ser Phe  
385 390 395 400

Leu Pro

15 (2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 1239 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA (synthetic)

25 (vi) ORIGINAL SOURCE:  
(A) ORGANISM: Homo sapiens  
(G) CELL TYPE: placenta

(ix) FEATURE:  
(A) NAME/KEY: CDS  
(B) LOCATION: 1..1239

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

35 ATG CCT CTG CAA CTC CTC CTG TTG CTG ATC CTA CTG GGC CCT GGC AAC 48  
Met Pro Leu Gln Leu Leu Leu Leu Ile Leu Leu Gly Pro Gly Asn  
1 5 10 15

40 AGC TTG CAG CTG TGG GAC ACC TGG GCA GAT GAA GCC GAG AAA GCC TTG 96  
Ser Leu Gln Leu Trp Asp Thr Trp Ala Asp Glu Ala Glu Lys Ala Leu  
20 25 30

45 GGT CCC CTG CTT GCC CGG GAC CGG AGA CAG GCC ACC GAA TAT GAG TAC 144  
Gly Pro Leu Leu Ala Arg Asp Arg Arg Gln Ala Thr Glu Tyr Glu Tyr  
35 40 45

50 CTA GAT TAT GAT TTC CTG CCA GAA ACG GAG CCT CCA GAA ATG CTG AGG 192  
Leu Asp Tyr Asp Phe Leu Pro Glu Thr Glu Pro Pro Glu Met Leu Arg  
50 55 60

55 AAC AGC ACT GAC ACC ACT CCT CTG ACT GGG CCT GGA ACC CCT GAG TCT 240  
Asn Ser Thr Asp Thr Thr Pro Leu Thr Gly Pro Gly Thr Pro Glu Ser  
65 70 75 80

60 ACC ACT GTG GAG CCT GCT GCA AGG CGT TCT ACT GGC CTG GAT GCA GGA 288  
Thr Thr Val Glu Pro Ala Ala Arg Arg Ser Thr Gly Leu Asp Ala Gly  
85 90 95



		GGG	GCA	GTC	ACA	GAG	CTG	ACC	ACG	GAG	CTG	GCC	AAC	ATG	GGG	AAC	CTG	336
		Gly	Ala	Val	Thr	Glu	Leu	Thr	Thr	Glu	Leu	Ala	Asn	Met	Gly	Asn	Leu	
					100						105				110			
5		TCC	ACG	GAT	TCA	GCA	GCT	ATG	GAG	ATA	CAG	ACC	ACT	CAA	CCA	GCA	GCC	384
		Ser	Thr	Asp	Ser	Ala	Ala	Met	Glu	Ile	Gln	Thr	Thr	Gln	Pro	Ala	Ala	
				115					120					125				
10		ACG	GAG	GCA	CAG	ACC	ACT	CAA	CCA	GTG	CCC	ACG	GAG	GCA	CAG	ACC	ACT	432
		Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Val	Pro	Thr	Glu	Ala	Gln	Thr	Thr	
			130					135					140					
15		CCA	CTG	GCA	GCC	ACA	GAG	GCA	CAG	ACA	ACT	CGA	CTG	ACG	GCC	ACG	GAG	480
		Pro	Leu	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Arg	Leu	Thr	Ala	Thr	Glu	
		145				150						155					160	
20		GCA	CAG	ACC	ACT	CCA	CTG	GCA	GCC	ACA	GAG	GCA	CAG	ACC	ACT	CCA	CCA	528
		Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Pro	
						165					170				175			
25		GCA	GCC	ACG	GAA	GCA	CAG	ACC	ACT	CAA	CCC	ACA	GCC	CTG	GAG	GCA	CAG	576
		Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Thr	Gly	Leu	Glu	Ala	Gln	
					180					185				190				
30		ACC	ACT	GCA	CCA	GCA	GCC	ATG	GAG	GCA	CAG	ACC	ACT	GCA	CCA	GCA	GCC	624
		Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Ala	Ala	
				195				200						205				
35		ATG	GAA	GCA	CAG	ACC	ACT	CCA	CCA	GCA	GCC	ATG	GAG	GCA	CAG	ACC	ACT	672
		Met	Glu	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	
			210					215					220					
40		CAA	ACC	ACA	GCC	ATG	GAG	GCA	CAG	ACC	ACT	GCA	CCA	GAA	GCC	ACG	GAG	720
		Gln	Thr	Thr	Ala	Met	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Glu	Ala	Thr	Glu	
		225				230						235					240	
45		GCA	CAG	ACC	ACT	CAA	CCC	ACA	GCC	ACG	GAG	GCA	CAG	ACC	ACT	CCA	CTG	768
		Ala	Gln	Thr	Thr	Pro	Pro	Thr	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Leu	
						245					250					255		
50		GCA	GCC	ATG	GAG	GCC	CTG	TCC	ACA	GAA	CCC	AGT	GCC	ACA	GAG	GCC	CTG	816
		Ala	Ala	Met	Glu	Ala	Leu	Ser	Thr	Glu	Pro	Ser	Ala	Thr	Glu	Ala	Leu	
				260				265						270				
55		TCC	ATG	GAA	CCT	ACT	ACC	AAA	AGA	GGT	CTG	TTC	ATA	CCC	TTT	TCT	GTG	864
		Ser	Met	Glu	Pro	Thr	Thr	Lys	Arg	Gly	Leu	Phe	Ile	Pro	Phe	Ser	Val	
				275				280						285				
60		TCC	TCT	GTT	ACT	CAC	AAG	GGC	ATT	CCC	ATG	GCA	GCC	AGC	AAT	TTG	TCC	912
		Ser	Ser	Val	Thr	His	Lys	Gly	Ile	Pro	Met	Ala	Ala	Ser	Asn	Leu	Ser	
				290				295					300					
65		GTC	AAC	TAC	CCA	GTG	GGG	GCC	CCA	GAC	CAC	ATC	TCT	GTG	AAG	CAG	TGC	960
		Val	Asn	Tyr	Pro	Val	Gly	Ala	Pro	Asp	His	Ile	Ser	Val	Lys	Gln	Cys	
		305				310					315						320	
70		CTG	CTG	GCC	ATC	CTA	ATC	TTG	GCG	CTG	GTG	GCC	ACT	ATC	TTC	TTC	GTG	1008
		Leu	Leu	Ala	Ile	Leu	Ile	Leu	Ala	Leu	Val	Ala	Thr	Ile	Phe	Phe	Val	
						325					330				335			
75		TGC	ACT	GTG	GTG	CTG	GCG	GTC	CGC	CTC	TCC	CGC	AAG	GGC	CAC	ATG	TAC	1056
		Cys	Thr	Val	Val	Leu	Ala	Val	Arg	Leu	Ser	Arg	Lys	Gly	His	Met	Tyr	
				340				345						350				
80		CCC	GTG	CGT	AAT	TAC	TCC	CCC	ACC	GAG	ATG	GTC	TGC	ATC	TCA	TCC	CTG	1104
		Pro	Val	Arg	Asn	Tyr	Ser	Pro	Thr	Glu	Met	Val	Cys	Ile	Ser	Ser	Leu	
				355				360					365					

```

      TTG CCT GAT GGG GGT GAG GGG CCC TCT GCC ACA GCC AAT GGG GGC CTG      1152
      Leu Pro Asp Gly Gly Glu Gly Pro Ser Ala Thr Ala Asn Gly Gly Leu
      370          375          380

5     TCC AAG GCC AAG AGC CCG GGC CTG ACG CCA GAG CCC AGG GAG GAC CGT      1200
      Ser Lys Ala Lys Ser Pro Gly Leu Thr Pro Glu Pro Arg Glu Asp Arg
      385          390          395          400

10    GAG GGG GAT GAC CTC ACC CTG CAC AGC TTC CTC CCT TAG      1239
      Glu Gly Asp Asp Leu Thr Leu His Ser Phe Leu Pro
      405          410

```

## (2) INFORMATION FOR SEQ ID NO:4:

15

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 412 amino acids

(B) TYPE: amino acid

(D) TOPOLOGY: linear

20

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

```

25    Met Pro Leu Gln Leu Leu Leu Leu Ile Leu Leu Gly Pro Gly Asn
      1          5          10          15

30    Ser Leu Gln Leu Trp Asp Thr Trp Ala Asp Glu Ala Glu Lys Ala Leu
      20          25          30

35    Gly Pro Leu Leu Ala Arg Asp Arg Arg Gln Ala Thr Glu Tyr Glu Tyr
      35          40          45

40    Leu Asp Tyr Asp Phe Leu Pro Glu Thr Glu Pro Pro Glu Met Leu Arg
      50          55          60

45    Asn Ser Thr Asp Thr Thr Pro Leu Thr Gly Pro Gly Thr Pro Glu Ser
      65          70          75          80

50    Thr Thr Val Glu Pro Ala Ala Arg Arg Ser Thr Gly Leu Asp Ala Gly
      85          90          95

55    Gly Ala Val Thr Glu Leu Thr Thr Glu Leu Ala Asn Met Gly Asn Leu
      100          105          110

      Ser Thr Asp Ser Ala Ala Met Glu Ile Gln Thr Thr Gln Pro Ala Ala
      115          120          125

```

	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Val	Pro	Thr	Glu	Ala	Gln	Thr	Thr	
	130						135					140					
5	Pro	Leu	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Arg	Leu	Thr	Ala	Thr	Glu	
	145					150					155					160	
	Ala	Gln	Thr	Thr	Pro	Leu	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Pro	
					165					170					175		
10	Ala	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Gln	Pro	Thr	Gly	Leu	Glu	Ala	Gln	
				180					185					190			
15	Thr	Thr	Ala	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Ala	Ala	
				195				200					205				
20	Met	Glu	Ala	Gln	Thr	Thr	Pro	Pro	Ala	Ala	Met	Glu	Ala	Gln	Thr	Thr	
	210					215					220						
25	Gln	Thr	Thr	Ala	Met	Glu	Ala	Gln	Thr	Thr	Ala	Pro	Glu	Ala	Thr	Glu	
	225				230					235					240		
	Ala	Gln	Thr	Thr	Gln	Pro	Thr	Ala	Thr	Glu	Ala	Gln	Thr	Thr	Pro	Leu	
				245				250						255			
30	Ala	Ala	Met	Glu	Ala	Leu	Ser	Thr	Glu	Pro	Ser	Ala	Thr	Glu	Ala	Leu	
				260				265					270				
35	Ser	Met	Glu	Pro	Thr	Thr	Lys	Arg	Gly	Leu	Phe	Ile	Pro	Phe	Ser	Val	
			275				280						285				
40	Ser	Ser	Val	Thr	His	Lys	Gly	Ile	Pro	Met	Ala	Ala	Ser	Asn	Leu	Ser	
			290			295					300						
45	Val	Asn	Tyr	Pro	Val	Gly	Ala	Pro	Asp	His	Ile	Ser	Val	Lys	Gln	Cys	
	305				310					315					320		
	Leu	Leu	Ala	Ile	Leu	Ile	Leu	Ala	Leu	Val	Ala	Thr	Ile	Phe	Phe	Val	
				325				330						335			
50	Cys	Thr	Val	Val	Leu	Ala	Val	Arg	Leu	Ser	Arg	Lys	Gly	His	Met	Tyr	
				340				345					350				
55	Pro	Val	Arg	Asn	Tyr	Ser	Pro	Thr	Glu	Met	Val	Cys	Ile	Ser	Ser	Leu	
			355			360				365							

Leu Pro Asp Gly Gly Glu Gly Pro Ser Ala Thr Ala Asn Gly Gly Leu  
 370 375 380

5 Ser Lys Ala Lys Ser Pro Gly Leu Thr Pro Glu Pro Arg Glu Asp Arg  
 385 390 395 400

Glu Gly Asp Asp Leu Thr Leu His Ser Phe Leu Pro  
 405 410

10

## (2) INFORMATION FOR SEQ ID NO:5:

## (i) SEQUENCE CHARACTERISTICS:

- 15 (A) LENGTH: 2151 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

20 (ii) MOLECULE TYPE: cDNA

## (vii) IMMEDIATE SOURCE:

(B) CLONE: pacesol

25

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

30 ATGGAGCTGA GGCCCTGGTT GCTATGGGTG GTAGCAGCAA CAGGAACCTT GGTCTGCTA 60  
 GCAGCTGATG CTCAGGGCCA GAAGGTCTTC ACCAACACGT GGGCTGTGCG CATCCCTGGA 120  
 GGCCCAGCGG TGGCCAACAG TGTGGCACGG AAGCATGGGT TCCTCAACCT GGGCCAGATC 180  
 35 TTCGGGGACT ATTACCACTT CTGGCATCGA GGAGTGACGA AGCGGTCCCT GTCGCCTCAC 240  
 CGCCCCGCGC ACAGCCGGCT GCAGAGGGAG CCTCAAGTAC AGTGGCTGGA ACAGCAGGTG 300  
 GCAAAGCGAC GGAATAACG GGACGTGTAC CAGGAGCCCA CAGACCCCAA GTTTCCTCAG 360  
 40 CAGTGGTACC TGTCTGGTGT CACTCAGCGG GACCTGAATG TGAAGGCGGC CTGGGCGCAG 420  
 GGCTACACAG GGCACGGCAT TGTGGTCTCC ATTCTGGACG ATGGCATCGA GAAGAACCAC 480  
 45 CCGGACTTGG CAGGCAATTA TGATCCTGGG GCCAGTTTTG ATGTCAATGA CCAGGACCCT 540  
 GACCCCCAGC CTCGGTACAC ACAGATGAAT GACAACAGGC ACGGCACACG GTGTGCGGGG 600  
 GAAGTGGCTG CGGTGGCCAA CAACGGTGTC TGTGGTGTAG GTGTGGCCTA CAACGCCCGC 660  
 50 ATTGGAGGGG TGCGCATGCT GGATGGCGAG GTGACAGATG CAGTGGAGGC ACGCTCGCTG 720  
 GGCCTGAACC CCAACCACAT CCACATCTAC AGTGCCAGCT GGGGCCCGGA GGATGACGGC 780  
 55 AAGACAGTGG ATGGGCCAGC CCGCCTCGCC GAGGAGGCCT TCTTCCGTGG GGTAGCCAG 840  
 GGCCGAGGGG GGCTGGGCTC CATCTTTGTC TGGGCCTCGG GGAACGGGGG CCGGGAACAT 900  
 GACAGCTGCA ACTGCGACGG CTACACCAAC AGTATCTACA CGCTGTCCAT CAGCAGCGCC 960  
 60 ACGCAGTTTG GCAACGTGCC GTGGTACAGC GAGGCCTGCT CGTCCACACT GGCCACGACC 1020

5      TACAGCAGTG GCAACCAGAA TGAGAAGCAG ATCGTGACGA CTGACTTGCG GCAGAAGTGC      1080  
ACGGAGTCTC ACACGGGCAC CTCAGCCTCT GCCCCCTTAG CAGCCGGCAT CATTGCTCTC      1140  
10      ACCCTGGAGG CCAATAAGAA CCTCACATGG CGGGACATGC AACACCTGGT GGTACAGACC      1200  
TCGAAGCCAG CCCACCTCAA TGCCAACGAC TGGGCCACCA ATGGTGTGGG CCGGAAAGTG      1260  
AGCCACTCAT ATGGCTACGG GCTTTTGGAC GCAGGCGCCA TGGTGGCCCT GGCCCAGAAT      1320  
15      TGGACCACAG TGGCCCCCCA GCGGAAGTGC ATCATCGACA TCCTCACCGA GCCCAAAGAC      1380  
ATCGGGAAC GGCTCGAGGT GCGGAAGACC GTGACCGCGT GCCTGGGCGA GCCCAACCAC      1440  
20      ATCACTCGGC TGGAGCACGC TCAGGCGCGG CTCACCCTGT CCTATAATCG CCGTGGCGAC      1500  
CTGGCCATCC ACCTGGTCAG CCCCATGGG ACCCGCTCCA CCCTGCTGGC AGCCAGGCCA      1560  
CATGACTACT CCGCAGATGG GTTTAATGAC TGGGCCTTCA TGACAACTCA TTCCTGGGAT      1620  
25      GAGGATCCCT CTGGCGAGTG GGTCCTAGAG ATTGAAAACA CCAGCGAAGC CAACAACATAT      1680  
GGGACGCTGA CCAAGTTCAC CCTCGTACTC TATGGCACCG CCCCTGAGGG GCTGCCCGTA      1740  
30      CCTCCAGAAA GCAGTGGCTG CAAGACCCTC ACGTCCAGTC AGGCCTGTGT GGTGTGCGAG      1800  
GAAGGCTTCT CCCTGCACCA GAAGAGCTGT GTCCAGCACT GCCCTCCAGG CTTGCCCCC      1860  
CAAGTCCTCG ATACGCACTA TAGCACCGAG AATGACGTGG AGACCATCCG GGCCAGCGTC      1920  
35      TGGCCCCCT GCCACGCCTC ATGTGCCACA TGCCAGGGGC CGGCCCTGAC AGACTGCCTC      1980  
AGTGCCCCA GCCACGCCTC CTTGGACCCT GTGGAGCAGA CTTGCTCCCG GCAAAGCCAG      2040  
40      AGCAGCCGAG AGTCCCCGCC ACAGCAGCAG CCACCTCGGC TGCCCCCGGA GGTGGAGGCG      2100  
GGGCAACGGC TCGGGGCAGG GCTGCTGCCC TCACACCTGC CTGAGTGATG A      2151

(2) INFORMATION FOR SEQ ID NO:6:

40      (i) SEQUENCE CHARACTERISTICS:  
            (A) LENGTH: 1591 base pairs  
            (B) TYPE: nucleic acid  
            (C) STRANDEDNESS: single  
45      (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

50      (vi) ORIGINAL SOURCE:  
            (A) ORGANISM: Homo sapiens

(vii) IMMEDIATE SOURCE:  
            (B) CLONE: sPSL.Fc

55      (xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

ATGCCTCTGC AACTCCTCCT GTTGCTGATC CTAAGGGCC CTGGCAACAG CTTGCAGCTG      60  
60      TGGGACACCT GGGCAGATGA AGCCGAGAAA GCCTTGGGTC CCCTGCTTGC CCGGGACCGG      120  
AGACAGGCCA CCGAATATGA GTACCTAGAT TATGATTTCC TGCCAGAAAC GGAGCCTCCA      180

	GAAATGCTGA GGAACAGCAC TGACACCACT CCTCTGACTG GGCCTGGAAC CCCTGAGTCT	240
	ACCACTGTGG AGCCTGCTGC AAGGCGTTCT ACTGGCCTGG ATGCAGGAGG GGCAGTCACA	300
5	GAGCTGACCA CGGAGCTGGC CAACATGGGG AACCTGTCCA CGGATTCAGC AGCTATGGAG	360
	ATACAGACCA CTCAACCAGC AGCCACGGAG GCACAGACCA CTCCACTGGC AGCCACAGAG	420
10	GCACAGACAA CTCGACTGAC GGCCACGGAG GCACAGACCA CTCCACTGGC AGCCACAGAG	480
	GCACAGACCA CTCCACCAGC AGCCACGGAA GCACAGACCA CTCAACCCAC AGGCCTGGAG	540
	GCACAGACCA CTGCACCAGC AGCCATGGAG GCACAGACCA CTGCACCAGC AGCCATGGAA	600
15	GCACAGACCA CTCCACCAGC AGCCATGGAG GCACAGACCA CTCAACCCAC AGCCATGGAG	660
	GCACAGACCA CTGCACCAGA AGCCACGGAG GCACAGACCA CTCAACCCAC AGCCACGGAG	720
20	GCACAGACCA CTCCACTGGC AGCCATGGAG GCCCTGTCCA CAGAACCCAG TGCCACAGAG	780
	GCCCTGTCCA TGGAACTTAC TACCAAAAGA GGTCTGTTCA TACCCTTTTC TGTGTCCTCT	840
	GTTACTCACA AGGGCATTCC CATGGCAGCC AGCAATTTGT CCGTCCTGCG CCCGCAGTCT	900
25	AGAGACAAAA CTCACACATG CCCACCGTGC CCAGCACCTG AACTCCTGGG GGGACCGTCA	960
	GTCTTCCTCT TCCCCC AAA ACCCAAGGAC ACCCTCATGA TCTCCCGGAC CCCTGAGGTC	1020
30	ACATGCGTGG TGGTGGACGT GAGCCACGAA GACCCTGAGG TCAAGTTCAA CTGGTACGTG	1080
	GACGGCGTGG AGGTGCATAA TGCCAAGACA AAGCCGCGGG AGGAGCAGTA CAACAGCACG	1140
	TACCGTGTGG TCAGCGTCCT CACCGTCCTG CACCAGGACT GGCTGAATGG CAAGGAGTAC	1200
35	AAGTGCAAGG TCTCCAACAA AGCCCTCCCA GTCCCCATCG AGAAAACCAT CTCCAAAGCC	1260
	AAAGGGCAGC CCCGAGAACC ACAGGTGTAC ACCCTGCCCC CATCCCGGGA GGAGATGACC	1320
40	AAGAACCAGG TCAGCCTGAC CTGCCTGGTC AAAGGCTTCT ATCCCAGCGA CATCGCCGTG	1380
	GAGTGGGAGA GCAATGGGCA GCCGGAGAAC AACTACAAGA CCACGCCTCC CGTGCTGGAC	1440
	TCCGACGGCT CCTTCTTCCT CTATAGCAAG CTCACCGTGG ACAAGAGCAG GTGGCAGCAG	1500
45	GGGAACGTCT TCTCATGCTC CGTGATGCAT GAGGCTCTGC ACAACCACTA CACGCAGAAG	1560
	AGCCTCTCCC TGTCCCCGGG TAAATAG	1591

5

CLAIMS

- 10 1. A composition comprising an isolated DNA sequence encoding a P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402.
- 15 2. A composition comprising an isolated DNA sequence encoding a soluble P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 310.
- 20 3. A composition comprising an isolated DNA sequence encoding a mature P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402.
- 25 4. A composition comprising an isolated DNA sequence encoding a soluble mature P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310.
- 30 5. A composition comprising an isolated DNA sequence encoding a P-selectin ligand protein, said protein being characterized by the amino acid sequence set forth in SEQ ID NO:3.
- 35 6. An isolated DNA sequence capable of hybridizing under stringent conditions to the DNA sequence of any one of claims 1, 2, 3, 4 or 5.
7. The DNA sequence of any one of claims 1, 2, 3, 4, 5 or 6 operably linked to an expression control sequence.
8. A host cell transformed with the DNA of claim 7.
- 40 9. The host cell of claim 8, comprising a mammalian cell.

10. A process for producing a P-selectin ligand protein, which comprises:

(a) culturing the host cell of claim 8 or claim 9 in a suitable culture medium; and

5 (b) purifying the P-selectin ligand protein from the culture medium.

11. A process for producing a soluble mature P-selectin ligand protein which comprises:

10 (a) co-transforming a host cell with the DNA sequence of claim 4, a DNA sequence encoding an ( $\alpha$ 1,3/ $\alpha$ 1,4) fucosyltransferase, and a DNA sequence encoding a paired basic amino acid converting enzyme, each of said DNA sequences being operably linked to an expression control sequence;

15 (b) culturing the host cell in a suitable culture medium; and

(c) purifying the soluble mature P-selectin ligand protein from the culture medium.

20 12. A composition comprising a P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402, said protein being substantially free from other mammalian proteins.

25 13. A composition comprising a P-selectin ligand protein characterized by the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 310, said protein being substantially free from other mammalian proteins.

30 14. The composition of claim 13, further comprising a pharmaceutically acceptable carrier.

15. A composition comprising a protein characterized by the amino acid sequence set forth in SEQ ID NO:3.

35

16. A composition comprising an antibody which specifically reacts with the P-selectin ligand protein of claim 12.



17. A composition comprising an antibody which specifically reacts with the P-selectin ligand protein of claim 13.

5 18. A composition comprising an antibody which specifically reacts with the protein of claim 15.

19. A method of identifying an inhibitor of P-selectin-mediated intercellular adhesion which comprises

10 (a) combining a P-selectin protein with a P-selectin ligand protein characterized by an amino acid sequence selected from the group consisting of the amino acid sequence set forth in SEQ ID NO:1 from amino acid 1 to amino acid 402, the amino acid sequence set forth in SEQ ID NO:1 from amino acid 42 to amino acid 402, the amino acid sequence set forth in SEQ ID NO:1 from amino acid 15 42 to amino acid 310, and the amino acid sequence set forth in SEQ ID NO:3, said combination forming a first binding mixture;

(b) measuring the amount of binding between the P-selectin protein and the P-selectin ligand protein in the first binding mixture;

20 (c) combining a compound with the P-selectin protein and the P-selectin ligand protein to form a second binding mixture;

(d) measuring the amount of binding in the second binding mixture; and

25 (e) comparing the amount of binding in the first binding mixture with the amount of binding in the second binding mixture; wherein the compound is capable of inhibiting P-selectin-mediated intercellular adhesion when a decrease in the amount of binding of the second binding mixture occurs.

30 20. A method of treating an inflammatory disease which comprises administering a therapeutically effective amount of the composition of claim 14 to a mammal.

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